JOINT WARFIGHTING SCIENCE AND TECHNOLOGY PLAN

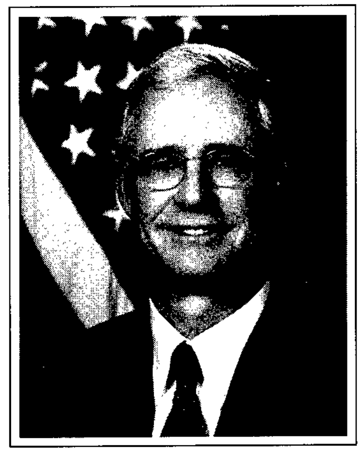
DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

JOINT
CHIEFS OF STAFF

February 1998

OFFICE OF THE SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301



The varied nature of military operations in a changing global environment requires U.S. Armed Forces to depend on the unique capabilities of each Military Service. The effective use of these capabilities requires that our Armed Forces operate as a fully integrated joint force. It is the responsibility of the acquisition community to ensure that our forces have the combat edge provided by technologically superior weapons. To maintain the technological superiority of today's weapons, it is essential that the Department pursues a focused, high quality, aggressive science and technology program, which is responsive to the interoperability and full spectrum dominance required by a joint force.

Over the last year, the Office of the Secretary of Defense, Joint Staff, Military Services, and Defense Agencies have again worked together to develop this third edition of the *Joint Warfighting Science and Technology Plan.* The plan serves to focus a portion of the DoD science and technology program on supporting future joint warfighting requirements and identifies ten Joint Warfighting Capability Objectives critical for maintaining a warfighting advantage. The Joint Requirements Oversight Council has validated the Joint Warfighting Capability Objectives upon which this plan is based.

The plan supports achievement of the operational concepts cited in *Joint Vision 2010* and addresses a variety of new threats present in the national security environment. It is also responsive to Section 270 of the National Defense Authorization Act for Fiscal Year 1997, which requires the annual submission of a plan for ensuring that the DoD science and technology program supports joint warfighting requirements.

Joseph W. Ralston

JOSEPH W. RALSTON
General, USAF
Vice Chairman
Joint Chiefs of Staff

J S Gansler

J. S. GANSLER
Under Secretary of Defense
(Acquisition and Technology)

JOINT WARFIGHTING SCIENCE AND TECHNOLOGY PLAN

February 1998

DEPARTMENT OF DEFENSE
DIRECTOR, DEFENSE RESEARCH AND ENGINEERING

CONTENTS

FIGURES

TABLES

CHAPTER I

INTRODUCTION

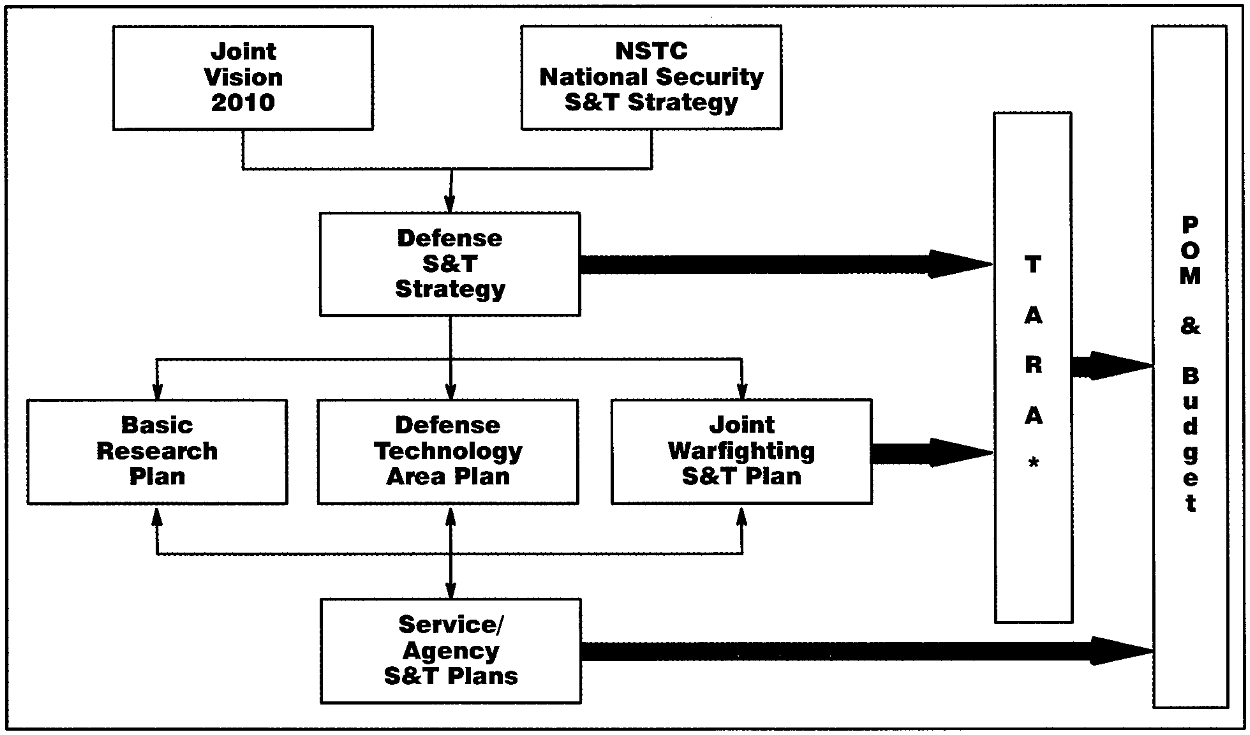
CHAPTER I
INTRODUCTION

Technological superiority has been, and continues to be, a cornerstone of our national military strategy. Technologies such as radar, jet engines, nuclear weapons, night vision, smart weapons, stealth, the Global Positioning System, and vastly more capable information management systems have changed warfare dramatically. Today's technological edge allows us to prevail across the broad spectrum of conflict decisively and with relatively low casualties. Maintaining this technological edge has become even more important as the size of U.S. forces decreases and high-technology weapons are now readily available on the world market. In this new environment, it is imperative that U.S. forces possess technological superiority to achieve and maintain the dominance displayed in Operation Desert Storm. The technological advantage we enjoy today is a legacy of decades of investment in science and technology (S&T). Likewise, our future warfighting capabilities will be substantially determined by today's investment in S&T.

The Director, Defense Research and Engineering (DDR&E), has strengthened the S&T strategic planning process to improve the S&T community's responsiveness to their warfighting and acquisition customers. Critical to this process is the *Defense Science and Technology Strategy* (Reference 1) with its supporting *Basic Research Plan* (BRP) (Reference 2), *Defense Technology Area Plan* (DTAP) (Reference 3), and this *Joint Warfighting Science and Technology Plan* (JWSTP). These documents present the DoD S&T vision, strategy, plan, and objectives for the planners, programmers, and performers of defense S&T. These documents are a collaborative product of the Office of the Secretary of Defense (OSD), Joint Staff, military services, and defense agencies. The strategy and plans are fully responsive to the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* (JV 2010) (Reference 4) and the National Science and Technology Council's (NSTC's) *National Security Science and Technology Strategy* (Reference 5), as shown in Figure I–1. These documents and the supporting individual S&T master plans of the military services and defense agencies guide the annual preparation of the DoD budget and program objective memorandums (POMs). The strategy and plans are made available to the U.S. Government, defense contractors, and our allies with the goal of better focusing our collective efforts on superior joint warfare capabilities and improving interoperability between the United States and our allies.

Defense Science and Technology Strategy (Reference 1). The *Defense Science and Technology Strategy* is responsive to the Secretary of Defense's vision to "develop and transition superior technology to enable affordable, decisive military capability." The overall S&T strategy is to "address the joint warfighters' stated needs, maintain a broad-based program spanning all defense-relevant sciences and technologies to anticipate future needs, support the unique needs of the military Departments, preserve long-range research, and do it within limited budgets." The strategy focuses on four generic considerations that have high priority in making strategic decisions about which technologies are pursued:

- *Affordability.* Where appropriate, S&T projects must focus on increasing the effectiveness of a capability and decreasing cost, increasing operational life, and incrementally improving material through planned upgrades.



* Technology Area Review and Assessment

Figure I–1. Science and Technology Strategic Planning

- *Dual Use.* The S&T program must contribute to building a common industrial base by using commercial practices, processes, and products, and by developing, where possible, technology that can be the base for both military and commercial products and applications.

- *Accelerated Transition.* Advanced Concept Technology Demonstrations (ACTDs) are a key element in the S&T program to focus science and technology on supporting military needs and problems, expediting transitions, and providing a sound basis for acquisition decisions.

- *Strong Technology Base.* Basic and applied research generate DoD's legacy to tomorrow's warfighter. Accordingly, it is imperative to maintain a stable technology base investment to develop options for the truly long term—beyond the threats, situations, and budgets that we can predict.

Basic Research Plan (Reference 2). The BRP presents the DoD objectives and investment strategy for DoD-sponsored basic research (6.1) performed by universities, industry, and service laboratories. In addition to presenting the planned investment in each of 12 Basic Research Areas across several technical disciplines composing the basic research program, the plan highlights six strategic research objectives holding great promise for the development of breakthrough technologies for revolutionary 21st century military capabilities:

- Biomimetics
- Nanoscience
- Smart structures
- Mobile wireless communications
- Intelligent systems
- Compact power sources

The coupling of the BRP with the DTAP and the JWSTP is carried out in several ways. First, the planning stage of the 12 individual research areas has the active participation of both the service laboratories and the warfighters (through the operating commands, such as the Army's Training and Doctrine Command (TRADOC)). This activity takes place by providing requirements and, oftentimes, serving on planning committees that focus on or include basic research. Second, representatives of the service laboratories and operating commands also take part in the program evaluation process through attendance and participation in service S&T program reviews and the ODDR&E Technology Area Reviews and Assessments (TARAs).

Defense Technology Area Plan (Reference 3). The DTAP presents the DoD objectives and the applied research (6.2) and advanced technology development (6.3) investment strategy for technologies critical to DoD acquisition plans, service warfighter capabilities, and the JWSTP. It takes a horizontal perspective across the service and defense agency efforts, thereby charting the total DoD investment for a given technology. The DTAP documents the focus, content, and principal objectives of the overall DoD S&T efforts. The DTAP includes a separate annex that provides an assessment of the potential technology capabilities of other countries vis-à-vis the United States.

Joint Warfighting Science and Technology Plan. This JWSTP also takes a joint perspective horizontally across the applied research (6.2) and advanced technology development (6.3) plans of the services and defense agencies, but for a different purpose. Its objective is to ensure that the S&T program supports priority future joint warfighting capabilities. The Joint Requirements Oversight Council (JROC) has endorsed the JWSTP planning process and methodology and the Joint Warfighting Capability Objectives (JWCOs) used in the development of the JWSTP. The 10 JWCOs are not all inclusive—there are other important joint and service-unique warfighting and operations other than war capabilities that need strong S&T support. Nevertheless the JWCOs provide an important focus for the S&T program.

This is the third edition of the *Joint Warfighting Science and Technology Plan.* It will be issued annually as defense guidance. Advanced concepts and technologies identified as enhancing high-priority joint warfighting capabilities, along with prerequisite research, will receive funding priority in the President's Budget and accompanying Future Years Defense Plan (FYDP).

Together, the BRP, DTAP, and JWSTP ensure that the near-, mid-, and far-term needs of the joint warfighter are properly balanced and supported in the S&T planning, programming, budgeting, and assessment activities of DoD.

Defense Technology Objectives (Reference 6). The S&T investment is focused and guided through Defense Technology Objectives (DTOs). Each DTO identifies a specific technology advancement that will be developed or demonstrated, the anticipated date of technology availability, the specific benefits resulting from the technology advance, and the funding required to achieve the new capability. These benefits not only include increased military operational capabilities but also address other important areas, including affordability and dual-use applications, that have received special emphasis in the *Defense Science and Technology Strategy.*

CHAPTER II

VISION AND STRATEGY

CHAPTER II
VISION AND STRATEGY

A. JOINT VISION 2010

The Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* (JV 2010) (Reference 4) is the conceptual template that provides a common direction to help the military services develop their unique capabilities within a joint framework of doctrine and programs. JV 2010 builds on the enduring foundation of high-quality people and innovative leadership. The traditional concepts of maneuver, strike, protection, and logistics are leveraged with *technological innovations* and *information superiority* to produce improvements that are potentially so powerful that they become, in effect, new operational concepts. As shown in Figure II–1, these operational concepts emerge as:

- *Dominant maneuver*—the multidimensional application of information and maneuver capabilities to provide coherent operations of air, land, sea, and space forces throughout the breadth, depth, and height of the battlespace to seize the initiative and control the tempo of the operation to a decisive conclusion.
- *Precision engagement*—the capability to accurately locate the enemy, command and control friendly forces, precisely attack key enemy forces or capabilities, and accurately assess the level of success.
- *Full-dimensional protection*—the capability to protect our forces at all levels and obtain freedom of action while they deploy, maneuver, and engage an adversary.
- *Focused logistics*—the capability to respond rapidly to crises, shift warfighting assets between geographic regions, monitor critical resources en route, and directly deliver tailored logistics at the required level of operations.

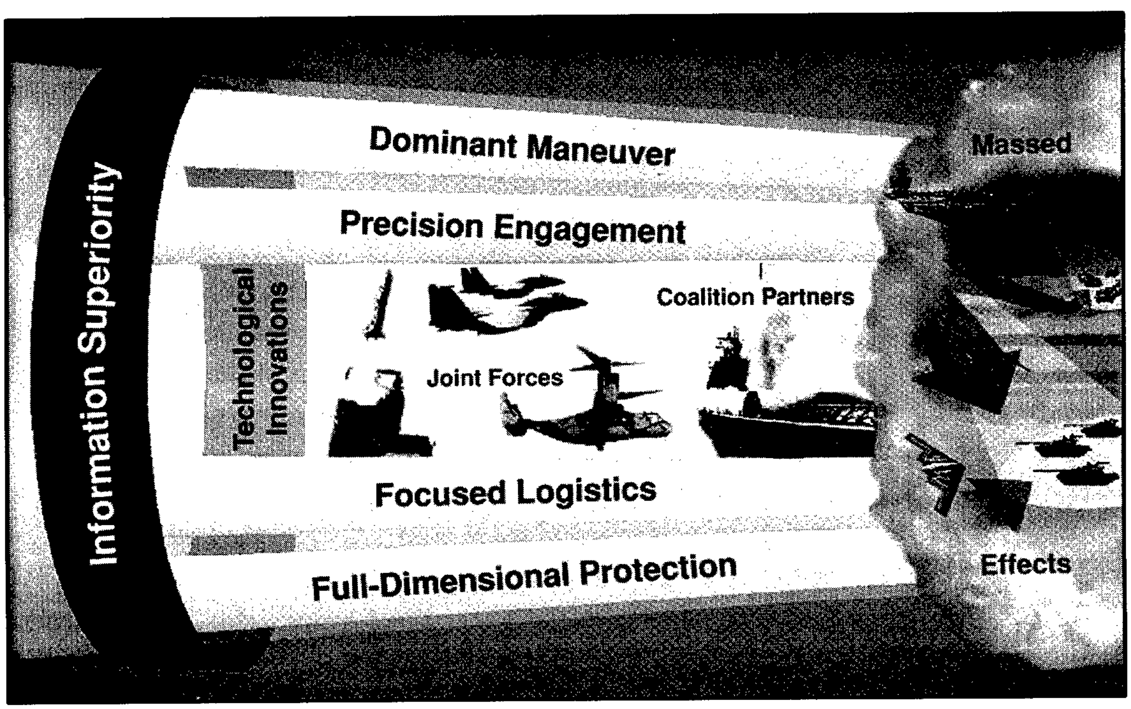


Figure II–1. The Concept of *Joint Vision 2010*

These new operational concepts interact to create the powerful, synergistic effect of *full-spectrum dominance*—the capability to dominate an adversary across the full range of military operations. Full-spectrum dominance emerges as a key characteristic of U.S. armed forces for the 21st century and will enable a smaller force to achieve swift, decisive victory with minimal casualties. A strong technological advantage will greatly assist in achieving this capability.

B. JOINT WARFIGHTING CAPABILITY OBJECTIVES

Achieving *Joint Vision 2010* will, in large measure, depend on the ability to achieve and exploit the 10 Joint Warfighting Capability Objectives (JWCOs) described below and discussed in detail in Chapters IV through XIII. These objectives, developed by the Joint Staff in collaboration with the Office of the Secretary of Defense (OSD) and the service science and technology executives, represent some of the most critical capabilities for maintaining the warfighting advantage of U.S. forces.

Figure II–2 is a pictorial representation of the JWCO methodology. The results of using the methodology are documented in 10 chapters that represent the core of this JWSTP (Chapters IV through XIII). This year's plan contains some new JWCOs, all validated by the JROC. These new capabilities were added to make the JWSTP more responsive to new dangers cited in *Report of the*

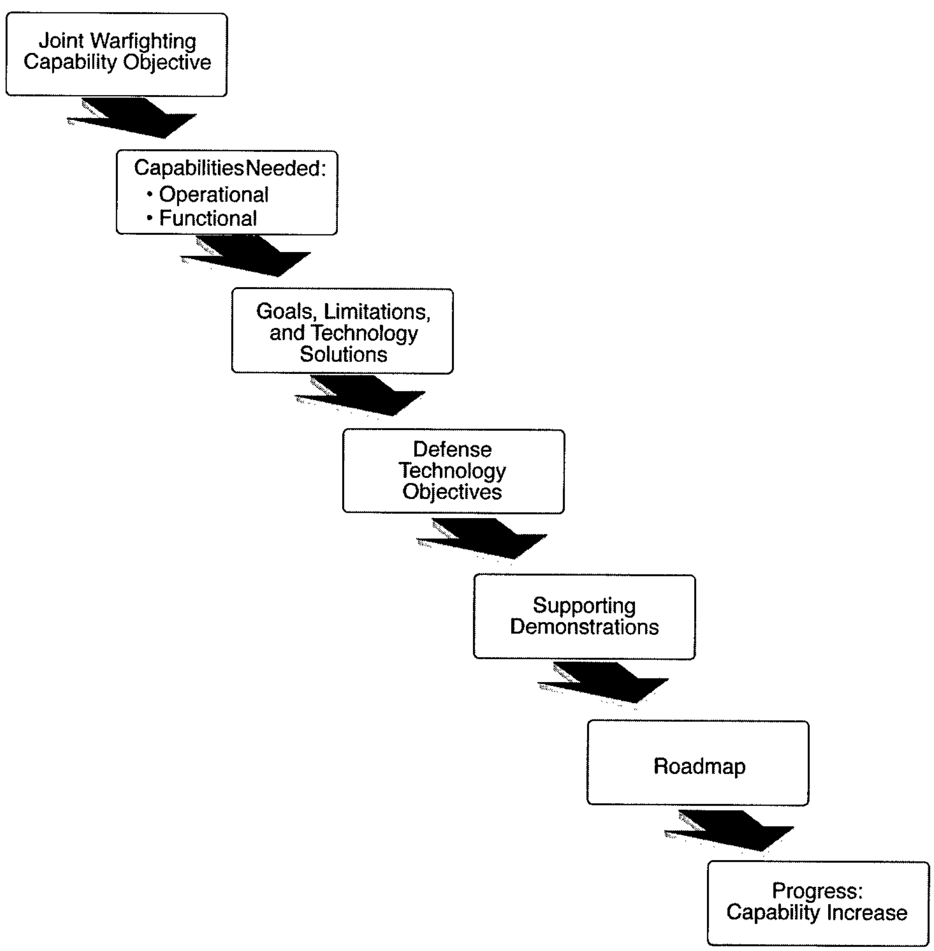


Figure II–2. Methodology for a Joint Warfighting Capability Objective

Quadrennial Defense Review (Reference 7) and *Report of the National Defense Panel* (Reference 8). Combating terrorism and the proliferation of weapons of mass destruction are two of the capabilities addressed.

The following are the JROC validated definitions of the JWCOs that make up this year's JWSTP.

Information Superiority combines the capabilities of intelligence, surveillance, and reconnaissance (ISR) and command, control, communications, computers, and intelligence (C^4I) to acquire and assimilate information needed to dominate and neutralize adversary forces and effectively employ friendly forces. It includes the capability for near-real-time awareness of the location and activity of friendly, adversary, and neutral forces throughout the battlefield area. It also includes a seamless, robust C^4 network linking all friendly forces to provide common awareness of the current situation throughout the battlefield area. Information superiority encompasses information warfare—that is, the capability to affect an adversary's information, information-based processes, information systems, and computer-based networks while defending one's own information, information-based processes, information systems, and computer-based networks.

Precision Force is the capability to destroy selected targets with precision while limiting collateral damage. It includes precision guided munitions, surveillance, targeting capabilities, and the "sensor-to-shooter" C^4I capabilities necessary for responsive, timely force application.

Combat Identification is the capability to differentiate potential targets as friend, foe, or neutral in sufficient time, with high confidence, and at the requisite range to support weapon release and engagement decisions.

Joint Theater Missile Defense is the capability to use the assets of multiple services and agencies to detect, track, acquire, and destroy enemy theater ballistic missiles and cruise missiles. It includes the seamless flow of information on missile launches and cruise missiles (before and after launch) within the framework of joint counter–air operations by specialized surveillance capabilities, through tracking by sensors from multiple services and agencies, to missile negation or destruction.

Military Operations in Urban Terrain (MOUT) is the capability to operate and conduct military operations in built-up areas and to achieve military objectives with minimum casualties and collateral damage. It includes precise weapons, surveillance, navigation, and communications effective in urban areas.

Joint Readiness & Logistics, and Sustainment of Strategic Systems is the capability to enhance readiness and logistics for joint and combined operations. It includes capabilities for enhanced simulation for training; improved and affordable operations and maintenance (O&M) and life-cycle costs; mobility and sustainability (i.e., transportation support technologies, such as airlift, sealift, and ground transportation); and near-term visibility of people, units, equipment, and supplies that are in storage, in process, in transit, or in theater, linked with the ability to act on this information. It also includes sustainment of strategic systems, which is the capability to sustain and upgrade existing strategic systems and to engineer, design, and develop strategic systems, including maintaining system safety; reducing system O&M cost; reducing reliance on existing strategic systems with advanced computing, simulation technologies, and advanced diagnostics; and retaining the engineering core competency for retrofits and replacements of materials unique to strategic systems.

Force Projection/Dominant Maneuver is the capability for fast deployment and timely employment and maneuver of joint forces to rapidly dominate across the full range of military operations with minimum casualties. This capability supports requirements to rapidly deploy and employ a decisive force with minimum use of lift resources and forward-based requirements. It includes enhanced capabilities in operational and tactical maneuver, joint countermine, individual and platform mobility, situation awareness, sustained logistics support, reconnaissance and intelligence, and integration of air-, land-, and sea-based maneuver and weapon systems. Joint countermine is the capability for assured, rapid surveillance, reconnaissance, detection, and neutralization of mines to enable forced entry by expeditionary forces. It also includes the capability to control the sea and to conduct amphibious and ground force operational maneuvers against hostile defensive forces employing sea, littoral, and land mines. For land forces, dominance means the ability to conduct in-stride tempo operations in the face of severe land mine threats.

Electronic Combat is the capability to disrupt or degrade an enemy's defenses throughout the area and time required to permit the deployment and employment of U.S. and allied combat systems. It includes the capabilities for deceiving, disrupting, and destroying the surveillance and command and control systems as well as the weapons of an enemy's integrated air defense network; and the capabilities for recognizing attempts by hostile systems to track or engage.

Chemical/Biological Warfare Defense & Protection and Counter Weapons of Mass Destruction (WMD) is the capability to detect and evaluate the existence of a manufacturing capability for WMD, and to identify and assess the weapon capability of alert and launched WMDs on the battlefield to permit the appropriate level of counterforce and force protection to be executed promptly. It includes counterforce against hardened WMD storage and production facilities and the capability for standoff detection of biological agents—our single most pressing need. Capabilities in both point and standoff detection of chemical and biological agents, combined with the ability to assess and disseminate threat information in a timely manner, are critical to protecting fielded forces.

Combating Terrorism is the capability to oppose terrorism throughout the threat spectrum, including antiterrorism (i.e., defensive measures to reduce vulnerability) and counterterrorism (i.e., offensive measures to prevent, deter, and respond). This capability includes personnel protection, assault, explosive detection and disposal, investigative science and forensics, physical security and infrastructure protection, surveillance, and collection, and enhanced support to allied land, sea, air, and riverine forces in the form of improved detection, monitoring and tracking, intelligence and logistics communications, training, and planning.

The JWCOs support the four operational concepts of JV 2010, as shown in Table II–1. A solid circle indicates strong support; an open circle, moderate support. Note that these areas of focus are descriptive rather than directive in nature and are subject to change.

Table II–1. Joint Warfighting Support of *Joint Vision 2010*

Joint Warfighting Capability Objectives	*Joint Vision 2010* Operational Concepts: Dominant Maneuver	Precision Engagement	Full-Dimensional Protection	Focused Logistics
Information Superiority	●	●	●	●
Precision Force	○	●	○	
Combat Identification	○	●	●	
Joint Theater Missile Defense		●	●	
Military Operations in Urban Terrain (MOUT)	●	○	●	
Joint Readiness and Logistics, and Sustainment of Strategic Systems	●	○	○	●
Force Projection/Dominant Maneuver	●	●	●	○
Electronic Combat	●	●	○	
Chemical/Biological Warfare Defense & Protection and Counter Weapons of Mass Destruction	●	●	●	○
Combating Terrorism		○	●	

● Strong Support ○ Moderate Support

C. JOINT WARFIGHTING CAPABILITY ASSESSMENTS

The Joint Warfighting Capabilities Assessment (JWCA) process—supported by the unified commanders-in-chief, services, and defense agencies—identifies opportunities for improving warfighting effectiveness. The JWCA must also take into consideration finding affordable S&T solutions to joint warfighting needs. This continuous process provides insights into issues involving joint warfighting requirements, readiness, plans for recapitalization, and support for joint requirements and resource recommendations. The Joint Requirements Oversight Council (JROC)—composed of the Vice Chiefs of the Army and the Air Force, the Vice Chief of Naval Operations, and the Assistant Commandant of the Marine Corps, and chaired by the Vice Chairman of the Joint Chiefs of Staff—oversees the JWCA process.

The relationship between the 12 JWCA areas and the 10 JWCOs is shown in Table II–2. Like Table II–1 above, the areas of focus (solid and open circles) are meant to be descriptive rather than directive and are subject to change.

Table II–2. Relationship Between Joint Warfighting Capability Assessment Areas and Joint Warfighting Capability Objectives

	JWCA Areas											
Joint Warfighting Capability Objectives	Land and Littoral Warfare	Strike	Sea, Air, and Space Superiority	Regional Engagement Presence	Strategic Mobility and Sustainability	Intelligence, Surveillance, and Reconnaissance	Command and Control	Information Operations	Combating Terrorism	Deter/Counter Proliferation	Reengineering Infrastructure	Joint Readiness
Information Superiority	●	●	●	●	○	●	●	●	●	●	○	●
Precision Force	●	●	●	○		●				○		○
Combat Identification	○	●	○			●	●		○	○		○
Joint Theater Missile Defense	●		○						○	●		○
Military Operations in Urban Terrain (MOUT)	●			○					○			○
Joint Readiness & Logistics, and Sustainment of Strategic Systems	○	○	○	○	●	○	○	○	○	●	●	●
Force Project/Dominant Maneuver	●	●	○	○	●	○	○			○		○
Electronic Combat		○	●					○				○
Chemical/Biological Warfare Defense & Protection and Counter Weapons of Mass Destruction	●				○	○			●	●		○
Combating Terrorism				○		○		●	●	●	○	○

● Strong Support ○ Moderate Support

D. S&T STRATEGIC PLANNING PROCESS

Oversight. The Director, Defense Research and Engineering (DDR&E), is responsible for the overall direction, quality, and content of the DoD S&T Program. The DDR&E has established an integrated S&T strategic planning process to effectively discharge these responsibilities. This process is accomplished and coordinated through Defense Science and Technology Reliance. Development of the BRP, DTAP, JWSTP, and supporting DTOs is the responsibility of the Defense S&T Reliance Executive Committee (EXCOM). Membership of the EXCOM is shown below:

Executive Committee
Deputy DDR&E, Chair
Deputy Assistant Secretary of the Army (Research and Technology)
Chief of Naval Research
Deputy Assistant Secretary of the Air Force (Science, Technology, and Engineering)
Deputy Director, Defense Advanced Research Projects Agency
Assistant Deputy Director for Technology, Ballistic Missile Defense Organization
Deputy Director, Defense Special Weapons Agency

When significant actions are undertaken, an Expanded EXCOM is convened to ensure the widest possible coordination within the DoD research and development community. The membership of the Expanded EXCOM is shown below:

Expanded Executive Committee
EXCOM Chair and Members
Deputy for Counterproliferation and Chemical/Biological Defense (CP&CBD)
Deputy Assistant Secretary of Defense for Health Affairs (Clinical Services)
Deputy Under Secretary of Defense for Advanced Technology
Deputy Under Secretary of Defense for Space
Deputy Chief of Staff for Research, Development and Acquisition, Army Materiel Command
Director of Navy Test and Evaluation and Technology Requirements, Office of the Chief of Naval Operations
Deputy for Science and Technology, Air Force Materiel Command
Chair, Joint Engineers
Chair, Training and Personnel Systems Science and Technology Evaluation Management Committee (TAPSTEM)

The preparation of the JWSTP is also guided by the Joint Warfighting Panel (JWP). The JWP consists of the following members:

Joint Warfighting Panel
EXCOM Chair and Members
Deputy Under Secretary of Defense (Advanced Technology)
Director, Force Structure, Resources and Assessment (J–8), Joint Chiefs of Staff

The EXCOM oversees the work of the Defense Committee on Research (DCOR), which is responsible for preparation of the BRP; the 10 technology area panels responsible for preparation of the DTAP; and the 10 JWCO panels responsible for preparation of the JWSTP. These plans build on—but do not duplicate—the service/agency S&T plans. They also consider recent technology forecasts such as OSD's *Revolution in Military Affairs*, the Army's *Force XXI* and *Army After Next*, the Navy's *Navy After Next*, the Air Force's *New World Vistas*, and the Marine Corps' *Sea Dragon* efforts.

To ensure that the integrated S&T planning is responsive to the strategy, the Defense S&T Reliance network has developed the following goals to guide the effort:

- Enhance the quality of Defense S&T activities and develop world-class products.
- Ensure the existence of critical masses of resources
- Reduce redundant S&T capabilities and eliminate unwarranted duplication.
- Gain productivity and efficiency through collocation and consolidation of in-house S&T work.
- Preserve the vital mission-essential capabilities of the services throughout the process.

Defense Technology Objectives. The focus of the S&T investment is enhanced and guided through Defense Technology Objectives (DTOs). Each DTO identifies a specific technology advancement that will be developed or demonstrated, the anticipated date of technology availability, the specific benefits resulting from the technology advance, and the funding planned to achieve the new capability. These benefits not only include increased military operational capabilities but also address other important areas, including affordability and dual-use applications, that have received special emphasis in the *Defense Science and Technology Strategy* (Reference 1). A key responsibility of the EXCOM is to review and approve DTOs. The total of approximately 350 DTOs represents some 50 percent of the total 6.2 and 6.3 FY99 funding.

The DTOs that support achievement of specific functional and operational capabilities within each JWCO are listed in Chapters IV through XIII for each of the 10 JWCOs. Collectively, the JWCOs and the supporting DTOs from the DTAP will receive 29 percent of the 6.2 and 6.3 budgets in FY99. Figures II–3 and II–4 show the funding allocation to the DTOs cited in this JWSTP, those cited in the DTAP, and the remainder of the 6.2- and 6.3-funded program. Not every needed technology program is captured in a DTO. If the entire DoD S&T program were to be defined by DTOs in the *Defense Science and Technology Strategy* and its supporting plans, the services and agencies would lack the flexibility to seize local opportunities. A balanced, innovative program requires that flexibility be retained at the service, agency, and local laboratory levels.

The full texts of the DTAP and JWSTP DTOs are contained in a separate volume entitled *Defense Technology Objectives of the Joint Warfighting Science and Technology Plan and Defense Technology Area Plan*, January 1998 (Reference 6). The DTOs are presented in two parts—one for the DTAP and one for this JWSTP. The DTO sequence numbers do not connote priorities.

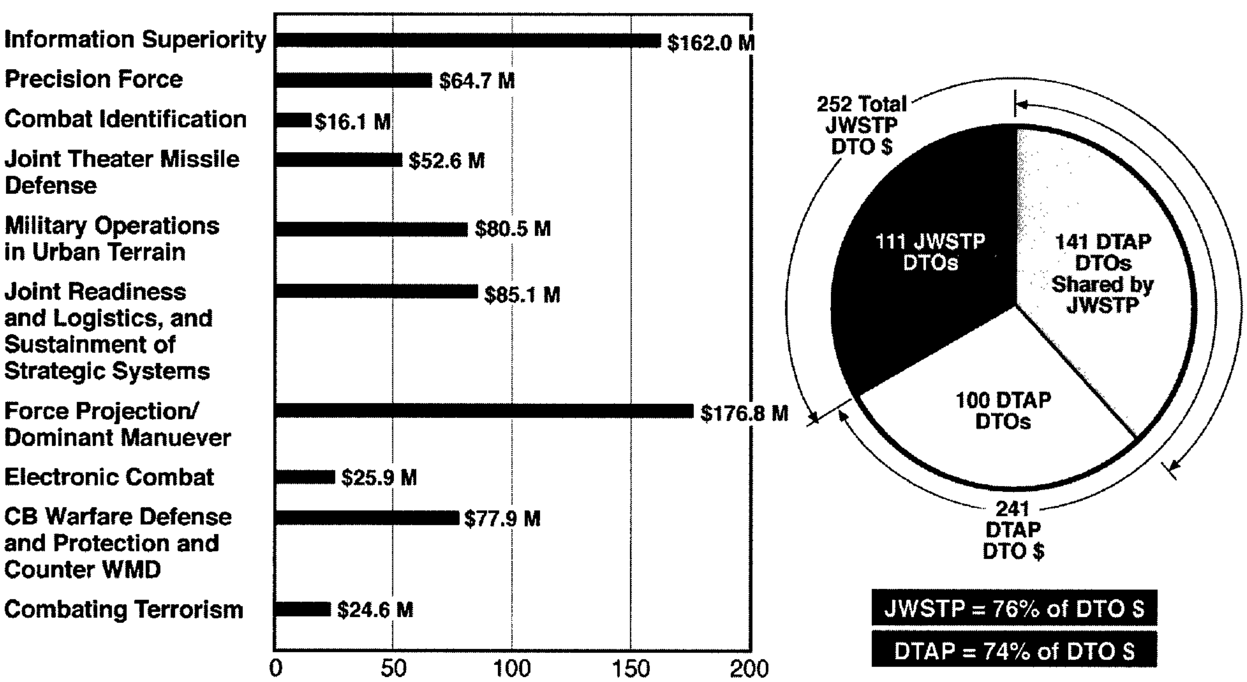


Figure II–3. Joint Warfighting Capability Objectives Funding, Fiscal Year 1999

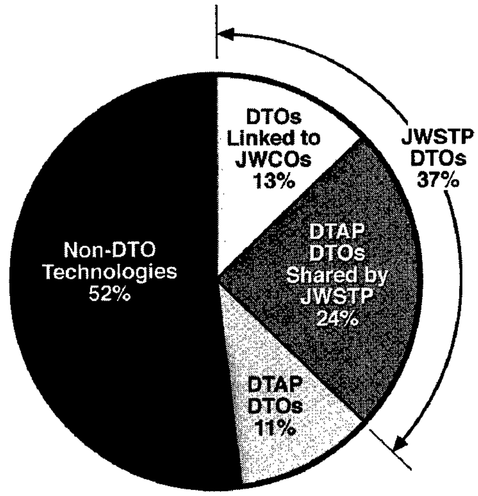


Figure II–4. DTO Share of Defense 6.2 and 6.3 Investment

JWSTP Development. The 10 JWCO panel chairs are responsible for preparing their respective JWSTP sections. JWCO panel membership consists of service representatives, appropriate defense agency technical specialists, and representatives from the Joint Chiefs of Staff. Most panels are chaired by a senior OSD or defense agency S&T manager. The 10 JWCO panel chairs are shown below:

JWCO Panel Chairs	
Information Superiority	Dr. Ann Miller, ODDR&E(IT)
Precision Force	Dr. Wes Kitchens, ODDR&E(WT)
Combat Identification	Mr. John Buchheister, OASD(C^3I)
Joint Theater Missile Defense	Dr. Wes Kitchens, ODDR&E(WT)
Military Operations in Urban Terrain	Ms. Carol Fitzgerald, SSCOM
Joint Readiness and Logistics, and Sustainment of Strategic Systems	Dr. Don Dix, ODDR&E(AT) (Chair) Mr. Brian Sharkey, DARPA (Co-Chair) Mr. Gary Yerace, DMSO (Co-Chair) RADM J. O. Allison, DSWA, OP (Co-Chair)
Force Projection/Dominant Maneuver	Dr. Wes Kitchens, ODDR&E(WT)
Electronic Combat	Mr. Anthony Grieco, OUSD(A&T)/S&TS/EW
Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction	Dr. George Ullrich, DSWA (Chair) Dr. Anna Johnson-Winegar, ODDR&E/ELS (Co-Chair) Dr. Salvatore Bosco, OATSD(CBM) (Co-Chair)
Combating Terrorism	Dr. Jasper Lupo, ODDR&E(SE)

Review and Assessment. After publication of the planning documents, Technology Area Reviews and Assessments (TARAs) are held for each of the 10 DTAP technology areas, the basic research program, and the manufacturing technology program. These reviews are conducted by

TARA teams, with at least two-thirds of their membership from outside DoD. Most TARA team members are recognized experts from the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, the Defense Science Board, the scientific advisory boards of the military departments, industry, and academia. The TARA team is chaired by a senior executive appointed by the DDR&E. The appropriate representatives from the Defense S&T Reliance Technical Panel brief the DoD program as compared to the planning guidance. Special S&T issues identified by the DDR&E and applicable JWSTP ACTDs and completed DTOs are also reviewed.

Following the review, the TARA chair briefs the findings and recommendations to the DDR&E-chaired Defense Science and Technology Advisory Group (DSTAG). Included in this briefing are the TARA chair's program recommendations for termination, adjustment, and enhancement to better align the S&T program to comply with the guidance. Based on recommendations and decisions of the DSTAG, the DDR&E briefs the issues to the Program Review Group (PRG), and program decision memorandums (PDMs) are issued as needed. The TARA process is shown in Figure II–5.

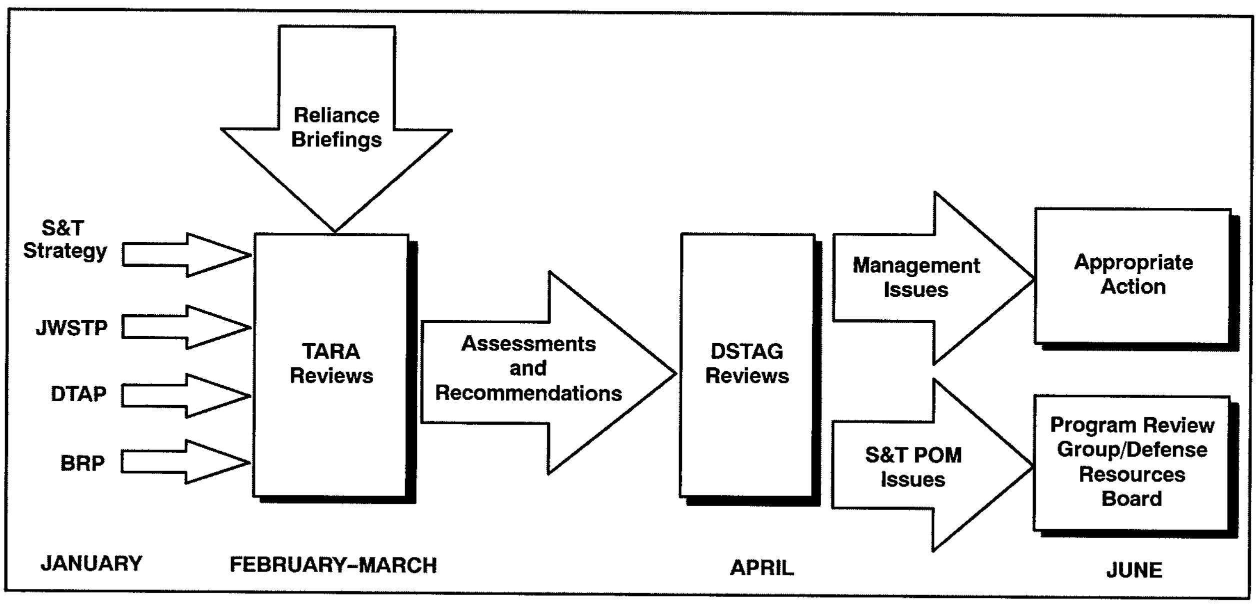


Figure II–5. Technology Area Review and Assessment Process

CHAPTER III

TRANSITION OF TECHNOLOGY TO THE JOINT WARFIGHTER

CHAPTER III

TRANSITION OF TECHNOLOGY TO THE JOINT WARFIGHTER

The cold war acquisition process produced some of the world's best military equipment. That process, however, is too expensive, and the time from concept to fielding is too long for the post-cold war budgetary and geopolitical environment. Three important mechanisms—Advanced Technology Demonstrations (ATDs), Advanced Concept Technology Demonstrations (ACTDs), and Joint Warfighting Experiments (JWEs)—are used to ensure the transition of innovative concepts and superior technology to the warfighter and acquisition customer both faster and less expensively than the traditional means. Each of these mechanisms is described below.

A. ADVANCED TECHNOLOGY DEMONSTRATIONS

Service and agency ATDs seek to demonstrate the maturity and potential of advanced technologies for enhanced military operational capability or cost effectiveness. The DTO volume for the JWSTP and the DTAP presents summary descriptions of the ATDs cited in this plan. ATDs are characterized by four parameters:

- Large scale, both in resources and complexity
- Operator/user involvement from planning to final documentation
- Specific cost, schedule, and performance metrics
- A clearly defined transition target.

B. ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

The ACTD process was initiated in 1994 to permit the early and inexpensive evaluation of mature advanced technologies. The evaluation is accomplished by the warfighter to determine military utility and to develop the concept of operations that will optimize effectiveness. ACTDs are structured and executed so that, when successful, we are able to proceed rapidly into formal acquisition.

By introducing new technologies in the field prior to the initiation of formal acquisition, we allow our operators, who have experience in combat, to evaluate and assess the military utility and develop the tactics to ensure that we can realize the full potential of the substantial technology base that is available to us—both defense and commercial. ACTDs are not a means by which to circumvent the formal acquisition process, but rather a means to enter that process based on a user assessment of the value of the new capability that reduces the user acceptance risk. This process will help us make more informed acquisition decisions and improve our acquisition cycle time.

ACTDs are designed to transfer technology rapidly from the developers to the users. They are user oriented and represent an integrated effort to assemble and demonstrate a significant, new or improved military capability that is based on mature advanced technologies. They also are on a scale large enough to demonstrate operational utility and end-to-end system integrity. A demonstration is jointly developed and implemented by the operational user and materiel development communities as key participants. ACTDs allow the warfighter to:

- Evaluate a technology's military utility before committing to a major acquisition effort.
- Develop concepts of operation for employing the new technology.
- Retain a low-cost residual operational capability if the commander desires.

Upon the conclusion of an ACTD, one of the following three choices will be made based on the results of the exercises:

- Execute the transition of the demonstrated technology directly to the warfighter. In this case, only minor, or perhaps no modifications, to the existing equipment will be required. This transition approach is particularly appropriate where only small quantities of the new equipment are required.
- Based on lessons learned during the ACTD, enter the formal acquisition process at the appropriate milestone.
- Terminate the efforts or restructure them based on the evolved concept of operations and lessons learned during the ACTD.

Over the past 4 years, ACTD proposals have been forwarded from the Joint Staff, unified commanders, and the military services. Suggestions have been received from industry and many DoD research and development agencies.

ACTDs come in all shapes and sizes. Some are just a few months in length and evaluate a very specific technology or address a particular mission area. Others are several years long and include coordination of multiple developing technology programs into a series of specific demonstrations. Although no two ACTDs are alike, and proposals are accepted at any time of year, there are some key points to consider before proposal submission:

- *Ensure the proposal addresses current or emerging military needs.* Some ACTDs deal with immediate military needs, such as the Counter-Sniper ACTD. Others explore emerging capabilities, such as the Information Operations Planning Tool ACTD.
- *ACTDs evaluate relatively mature technologies.* That is, their technical feasibility and technical risk are understood and have been demonstrated. The ACTD evaluates the operational application and military utility of the technologies.
- *User participation.* A key objective of each ACTD is to determine potential military utility of the technologies and to recommend whether further procurement is warranted. Each ACTD is a balance between operational needs and technological opportunity and requires close coordination and teaming between operators and developers.

ACTDs that examine the potential of specific technologies to address immediate or urgent needs can be submitted at any time. All ACTD proposals, including recommendations on potential participants, are coordinated between the Under Secretary of Defense (Acquisition and Technology) (USD(A&T)) and the Vice Chairman of the Joint Chiefs of Staff, based on prioritization from the Joint Requirements Oversight Council and reviews by the ACTD "Breakfast Club." Generally, the submission process for in-cycle ACTDs has developed into the following annual schedule:

- By the middle of January, all ACTD proposals should be submitted to DUSD(AT) by the services, joint staff, and various agencies.

- Beginning in the middle of February, DUSD(AT) will conduct feasibility checks and assemble one- to three-page descriptions for each of the ACTD candidates. Following an initial AT scrub of the programs, the list will be pared down to approximately 25 candidates.
- Starting in April, ACTD Breakfast Club briefings will be given to review each of the candidates. Breakfast Club grading will consider risk in the following categories: technical, management, funding, and ACTD suitability.
- DUSD(AT) will brief the Joint Requirements Board and Joint Requirements Oversight Council (JROC) on remaining candidates. Following this briefing, the JROC will prioritize the ACTD candidates. This prioritization process includes inputs from all CINCs, services, and Joint Warfighting Capability Assessment teams.
- The AT final scrub process (an in-depth review of each remaining candidate) will then be conducted through the middle of September, at which time DUSD(AT) will make the final ACTD selection. Following coordination with the Vice Chairman, Joint Chiefs of Staff, and the USD(A&T), DUSD(AT) will announce the final ACTD selections during the middle of October.

Out-of-cycle ACTDs are reviewed and initiated on a schedule established on a case-by-case basis.

The DUSD(AT) recently announced the selection of 14 ACTDs for FY98. In FY95, the Department of Defense initiated the first 11 ACTDs. Ten ACTDs were initiated at the beginning of FY96, and two more were added later in the fiscal year. During FY97, seven ACTDs were initiated at the beginning of the fiscal year, and two more were added later in the year. These ACTDs leverage in excess of $1 billion in military service and DoD agency technology programs.

The tabulation beginning on the next page provides brief summaries of the 46 ACTDs that were initiated in FY95, FY96, FY97, and FY98. Six of these have been completed. The DUSD(AT) web site [http://www.acq.osd.mil/at] and the ACTD Master Plan (Reference 9) provide more details of the ACTD implementation process and discuss the current status of existing ACTDs. The DTO volume (Reference 6) for the JWSTP and the DTAP presents summary descriptions for all ACTDs cited in this plan.

ADVANCED CONCEPT TECHNOLOGY DEMONSTRATIONS

ONGOING ACTDs

***Advanced Joint Planning* (User sponsor: U.S. Atlantic Command), DTO F.02**

Purpose: To enhance joint operational planning capabilities by leveraging, refining, and integrating emerging technologies. The Joint Readiness Automated Management System (JRAMS) allows planners to rapidly assess force readiness from a variety of databases and employ these data in viewing potential courses of action. The Time-Phased Force Deployment Data Editor (TPEDIT) is a planning tool developed in the ACTD that allows planners to view, create, and edit the contents of the Time-Phase Force Deployment Database. Both tools were developed and used operationally in less than a year and have been used to assess readiness and courses of action in a wide range of contingencies. These two planning tools have cut the time for contingency planning at U.S. Atlantic Command from in excess of 7 days in 1994 to approximately 2 hours today. The tools are undergoing transition into the Global Command and Control System common operating environment. FY97 has been used to transition selected tools into the GCCS Leading Edge Services and to position the overall system for hardening and sustainment by the ACOM user.

***High-Altitude Endurance Unmanned Aerial Vehicle (HAE UAV)* (User sponsor: U.S. Atlantic Command), DTO A.10**

Purpose: To address the military utility of an HAE UAV reconnaissance and surveillance capability at an air vehicle flyaway price of $10 million. Two classes of air vehicles are being developed: a conventional design (Global Hawk) and a low-observable (DarkStar) design. Global Hawk has completed successful wing load, environmental control system, landing gear, navigation system testing, and low- and medium-speed taxi tests, and is scheduled for first flight in the second quarter of FY98. DarkStar's first flight was successful, but the second flight ended in a crash during takeoff. In response to the accident investigation board-identified deficiencies, hardware and software modifications to Air Vehicle No. 2 are being implemented, with the design changes included in subsequent air vehicles.

***Joint Countermine* (User sponsor: U.S. Atlantic Command), DTO G.04**

Purpose: To demonstrate the capability to conduct effective, seamless amphibious mine countermeasure operations from sea to land; to provide simulation tools for Joint Countermine operations; and to define a Joint Countermine command, control, communications, and intelligence (C^3I) architecture. The initial demonstration occurred in summer 1997 under U.S. Atlantic Command sponsorship. Assessment of Demo I is currently in progress. Planning for Demo II is underway for inclusion in a summer 1998 exercise.

***Precision Signals Intelligence Targeting Systems (PSTS)* (User sponsor: U.S. Forces Korea), DTO B.03**

Purpose: To develop and demonstrate a near-real-time, precision targeting, sensor-to-shooter capability using existing national and tactical assets. PSTS is developing advanced cooperative precision targeting algorithms, processing enhancements, site interface necessary for cooperative operation, and a concept of operations for asset cooperative utilization and minimal operational impact. This ACTD is being executed as a series of demonstrations that incrementally improve the overall capability in terms of complexity of emitters that can be targeted, degree of engineer versus operator involvement, and tactical utility. A demonstration in Korea and Hawaii was completed in October 1996. The SIGINT data were collected by assets in Korea and by national means, processed in Hawaii, and transmitted to warfighters in Korea over existing SIGINT dissemination communication links. Planning for the fifth demonstration during the spring of 1998 and eventual interim capability are currently underway.

***Rapid Force Projection Initiative* (User sponsor: XVIII Airborne Corps), DTO M.05**

Purpose: To demonstrate sensor-to-standoff killer capability for light early-entry forces. The lethality and survivability of light Army entry forces will be enhanced by the capability to engage high-value targets, including heavy armor, beyond direct-fire ranges. A series of partial demonstrations is planned leading up to a full-scale, free-play demonstration in the fourth quarter of FY 1998. This final demonstration will occur at Fort Benning, Georgia, and will include both live and virtual forces.

***Synthetic Theater of War (STOW)* (User sponsor: U.S. Atlantic Command), DTO F.01**

Purpose: To provide an operational demonstration of advanced distributed simulation technologies that will directly support joint training and mission rehearsal. An additional goal is to effect the transition of the STOW technologies to the next generation of DoD simulations such as the Joint Simulation System (JSIMS), Joint Warfare Simulation (JWARS), and service simulations. In October 1997, STOW will participate in Atlantic Command's Unified Endeavor exercise and demonstrate high-resolution (platform-level) simulation technologies required to implement a Joint Task Force (JTF)-level exercise; interfaces to operational command, control, communications, computers, and intelligence (C^4I) systems, instrumented ranges, and virtual simulations; and environmental effects across a variety of operation types (e.g., antimine, theater missile defense, battlefield resupply). The exercise scenario included combined operations with the U.K. participating in STOW.

***Airbase/Port Biological Detection* (User sponsors: U.S. Central Command, U.S. Pacific Command (U.S. Forces Korea)), DTO I.03**

Purpose: To demonstrate an interim capability to automatically detect and identify in near-real time a biological attack on an airbase or port facility. This capability can potentially prevent mass casualties and maintain operational effectiveness at the facility. A modified Interim Biological Agent Detector (IBAD)—which includes an integrated, automated agent identification capability—has been developed and has successfully met ACTD objectives for timeliness and sensitivity during testing at Dugway Proving Ground against four biological agent simulants. This device represents a significant enhancement in capability, detection sensitivity, and time from detection to warning. Initial deployment of the ACTD sensor network will begin in late 1998 in the Republic of South Korea. A typical network will consist of 24 sensors configured to provide coverage of the entire base.

***Battlefield Awareness and Data Dissemination (BADD)* (User sponsor: U.S. Atlantic Command), DTO A.07**

Purpose: To develop, install, and evaluate a prototype operational system that allows commanders to design their own information system; delivers to warfighters an accurate, timely, and consistent picture of the battlefield; and provides access to any transmission mechanisms and worldwide data repositories. Pre-BADD ACTD efforts were briefed to the Defense Science Board as a possible option to enhance intelligence dissemination in support of Operation Joint Endeavor. This resulted in the creation of the Bosnia Command and Control Augmentation (BC^2A) currently operating in theater. This represents a significant enhancement in data dissemination capabilities using the Joint Broadcast System. Phase I of BADD was developed by DARPA, with CECOM as executive agent, and was focused on demonstration of key capabilities to disseminate data to battalion Tactical Operations Centers during the Task Force XXI Advanced Warfighting Experiment. Phase II is enhancing and maturing these systems to develop a pilot information management service in support of the Global Broadcast Service on UHF Follow-On (UFO) satellites 8, 9, and 10.

***Combat Identification* (User sponsor: U.S. Atlantic Command), DTO C.02**

Purpose: To demonstrate system alternatives that can enhance the capability of our combat forces to positively identify friendly and hostile platforms during air-to-ground and ground-to-ground operations in order to preclude fratricide due to misidentification and to maximize combat effectiveness. The Battlefield Combat Identification System (BCIS) was installed on the vehicles of the 4th Infantry division to provide training during the Task Force XXI exercise. The Situation Awareness Beacon with Reply (SABER) prototype units that were demonstrated at ASCIET 95 are currently deployed with the 22 MEU. Three major field events were conducted in FY 1997: Task Force XXI at Fort Irwin, California; All-Service Combat Identification Evaluation Team at Camp Shelby, Mississippi; and an international demonstration in Germany.

***Combat Vehicle Survivability* (User sponsor: III Corps)**

Purpose: To demonstrate a modest cost enhancement suite that significantly increases the survivability of combat vehicles on the battlefield. The Management Plan was signed on 30 September 1996.

***Counterproliferation I* (User sponsor: U.S. European Command with participation from U.S. Atlantic Command, U.S. Strategic Command, U.S. Pacific Command, and U.S. Special Operations Command), DTO J.03**

Purpose: To develop, integrate, demonstrate, and deliver to warfighters a militarily ready capability to characterize, destroy, and disrupt fixed nuclear, biological, and chemical (NBC) facilities and minimize collateral effects. The program will deliver an end-to-end system of sensors, target planning systems, and advanced weapons to improve warfighting capabilities against NBC targets. USEUCOM is the operational sponsor. Phase I consisted of a series of attacks on earth-mounded concrete masonry simulated biological storage facilities. Phase I was completed in February 1997 with the successful demonstration of a target attack planning and collateral effects prediction system, and the Hard Target Smart Fuze (HTSF). An interim demonstration series called Dipole Tiger (DT) was conducted in response to the sponsor's need to understand the baseline capability of current weapons to attack an above-ground, soft, chemical production facility while minimizing collateral effects. The DT tests highlighted the need to keep weapon fragmentation patterns away from agent storage vessels. Phase II will consist of a series of attacks on a hardened, reinforced concrete facility with a burster slab protecting a simulated chemical weapon production capability. Sensors, target planning tools, and advanced weapon systems will be demonstrated during the final demonstration testing, to be conducted from January through July 1998.

***Joint Logistics* (User sponsors: U.S. Pacific Command, U.S. Central Command), DTO F.19**

Purpose: To provide the users (CINCs and commanders, Joint Task Force) with the capability to rapidly plan and execute more responsive and efficient logistics support to military operations. A prototype network of workstations and commercial technologies has been developed and deployed to provide state-of-the-art planning tools, coupled with asset visibility, for Operation Joint Endeavor. This prototype system is the foundation for advanced capabilities being developed by the Defense Advanced Research Projects Agency (DARPA), the services, and other logistics agencies.

***Joint Readiness Extension to the Advanced Joint Planning ACTD* (User sponsor: Joint Staff)**

Purpose: To provide tools to the Joint Staff and unified commands to assist in automation of the Joint Monthly Readiness Report (JMRR). The first demonstration of automated tools to assist in preparation of the JMRR was completed in August 1996. An additional prototype was delivered in November 1996. The follow-on version is currently being tested and segmented. This effort will build on technologies employed and lessons learned in the Advanced Joint Planning ACTD.

Miniature Air-Launched Decoy Program **(User sponsor: Air Combat Command), DTO H.04**

Purpose: To develop and demonstrate a small, very inexpensive air-launched decoy system for the suppression of enemy air defense (SEAD) mission. MALD will greatly enhance the survivability of friendly aircraft and aid in establishing air superiority by stimulating, diluting, and confusing enemy integrated air defense systems. The MALD ACTD is a follow-on to the DARPA Small Engine Advanced Program (SENGAP), which successfully developed an extremely small turbojet engine. The 30-month ACTD contract was awarded to Teledyne Ryan Aeronautical Corporation on 5 November 1996. The program has successfully completed the critical design review and is on track for first flight in mid 1998.

Navigation Warfare **(User sponsor: U.S. Atlantic Command), DTO A.16**

Purpose: To validate the technologies and concept of operations for implementing protection of our use of satellite navigation systems and prevention of an adversary's use of satellite navigation systems. This capability will mitigate hostile use of satellite navigation by unfriendly forces on the battlefield while ensuring unimpeded use of the Global Positioning System for U.S. and allied forces.

Semiautomated Imagery Processing **(User sponsor: U.S. Atlantic Command), DTO A.09**

Purpose: To significantly improve an image analyst's ability to provide accurate, timely situation awareness to the warfighter. This system will allow analysts to exploit the output of an increasing quantity of image collection assets. A laboratory demonstration of the integrated system capability was held in October at Lincoln Laboratory. Initial field tests were conducted in March 1997 with the 18th Airborne Corps using the ETRAC ground station as a radar interface.

Tactical Unmanned Aerial Vehicle (TUAV) **(User sponsors: U.S. Army Training and Doctrine Command, U.S. Marine Corps Deputy Chief of Staff (Aviation), and Commander, Naval Air Forces, Atlantic Fleet), DTO A.14**

Purpose: To procure and support low-cost TUAV systems for use by brigade-level commanders; to develop CONOPS; to refine the TUAV requirements of the U.S. Army, Navy, and Marine Corps; and, if successful, to develop a path to full production of the TUAV. A contract for the TUAV was awarded in May 1996. As of November 1997, Outrider has successfully completed over 17 flights with a cumulative flight time of 5 hours and 41 minutes.

Chemical Enhancement to Airbase/Port Biological Detection **(User sponsors: U.S. Central Command and U.S. Pacific Command), DTO I.05**

Purpose: To (1) integrate a networked chemical warning capability using mature and available technologies to automatically detect and identify, in near-real time, chemical threats within the designated areas of operations associated with the Airbase/Port Biological Detection ACTD; (2) accelerate the demonstration of a Joint Warning and Reporting Network (JWARN); and (3) provide an interim capability to support the Commander In Chiefs (CINCs) for 2 years after the demonstration. The process of integrating the chemical and biological detection systems began in FY97. Full operational testing with simulated chemical and biological attacks will be conducted in FY98 at Dugway Proving Ground, Utah.

Consequence Management **(Sponsor: Marine Corps)**

Purpose: To demonstrate the capability to detect and model, inside a building, a biological warfare (BW) agent simulant for consequence management. Although BW agent detection suites are currently fielded with operational battlefield units, this is the first opportunity for the Army's Technical Escort Unit (TEU) and the Marine Corps' Chemical Biological Incident Response Force (CBIRF) to work together and acquire BW agent sensors and exercise sampling techniques suited for a rapid response, consequence management mission. The Consequence Management ACTD is scheduled for completion in the second quarter of FY98.

***Counterproliferation II* (User sponsors: U.S. European Command), DTO J.04**

Purpose: To develop, integrate, demonstrate, and effect the transition to the warfighters a militarily ready capability to deny, disrupt, or defeat a potential adversary's NBC related facilities while minimizing the potential for collateral effects and providing more reliable bomb damage and collateral effects assessments. Top-level driving requirements include an effective high-confidence planning process; accurate prediction, control, and assessment of collateral effects; and prompt response and reliable standoff kill. While the CPI ACTD has and will continue to improve CP Counterforce capabilities, the CPII ACTD will broaden the range of attack options available to commanders and reduce risks associated with the CP counterforce mission. Three operational demonstration series are planned over the period of FY99–02 to provide the sponsor and participating commands with opportunities to assess the operational utility of select technology component capabilities.

***Extending the Littoral Battlespace (ELB)* (User sponsor: Commander in Chief, U.S. Pacific Command), DTO M.02**

Purpose: To exploit the potential of mature and emergent technological capabilities to provide theater-wide situational awareness, sensor networks, effective remote fires, and a robust interconnected information infrastructure. This ACTD is a concept-based demonstration to enhance joint expeditionary warfare capabilities for the next century, complementing the Chairman of the Joint Chiefs of Staff's vision in the areas of Information Superiority, Precision Engagement, Dominant Maneuver, and Focused Logistics. FY98 will be given over to planning, systems engineering and integration, long-lead preparation for the systems demonstration in FY99, and integrated feasibility demonstrations of candidate technical solutions to the technical challenges of the system. FY00 will be devoted to refining open system architecture and preparing for Demo II in FY00.

***Information Operations Planning Tool (IOPT)* (User sponsor: U.S. Central Command), DTO A.25**

Purpose: To demonstrate how information operations (IO) planning, modeling, and analysis tools can aid in the effective prosecution of a CINC's battle objectives. These automated tools will provide capabilities supporting the planning, development, synchronization, deconfliction, and management of an integrated IO campaign involving HQ Central Command's J3 staff and the CINC components. The ACTD will also provide the modeling and analysis tools supporting Integrated Air Defense System (IADS) target recommendation development aligned with CINC IO taskings. In FY98, the IOPT will be demonstrated and evaluated for an optional 2-year interim capability. Included in this evaluation is an option for an FY99 demonstration to support the transition of select, proven technologies from the IOPT into acquisition and fielding.

***Integrated Collection Management (ICM)* (User sponsors: U.S. Atlantic Command), DTO A.05**

Purpose: To develop and demonstrate a significant new capability for a Joint Force Commander to take diverse national, theater, and tactical sensors and dynamically focus them as a joint force surveillance system-of-systems. The ICM tools will interface with existing and developing collection management tools. The program will significantly improve the ability for CINCs, commanders of Joint Task Forces, and their component commanders to use their own, and higher echelon, shared sensors in coordinated (cross-cued) and cooperative (simultaneous) collection strategies against time-critical targets and for force protection. Engineering design reviews for Phase I were held in FY97. Prototype design review will be completed, and implementation and initial testing commenced, early in FY98. Site survey for initial test, initial user training, development of demonstration concept of operations, C^2 definition, and test/demonstration design will be completed in early spring of 1998.

***Joint Advanced Health and Usage Monitoring System (JAHUMS)* (User sponsors: N/A), DTO F.18**

The JAHUMS ACTD is a multiservice demonstration and evaluation of an advanced helicopter health and usage monitoring system. The primary thrust of the ACTD is to demonstrate and document—in a controlled, multiaircraft environment—significant improvements in helicopter safety, reliability, operational availability, and return on investment through the use of emerging health and usage monitoring technologies and the judicious use of open systems standards and architectures. The JAHUMS ACTD begins in 1997 and extends through early 2001 with interim capability continuing through the latter half of 2001.

Military Operations in Urban Terrain (MOUT) **(User sponsors: U.S. Special Operations Command), DTO E.02** *Purpose:* Urban centers have increasingly become the sites of conflict throughout the world and will remain so as we move into the 21st century. The nature and complexity of the urban environment mandates manpower-intensive operations due to line-of-sight restrictions, inherent fortifications, limited intelligence, densely compacted areas, the presence of noncombatants, and associated restrictive rules of engagement. Due to the difficulty in controlling operations, MOUT operations have much higher potential for casualties and collateral damage than operations in other environments. The MOUT sites at Fort Benning and Camp Lejeune are in the process of being instrumented to include position/location in x-y-z coordinates; weapons effects adjudication; communications tagging; and video playback and linkage to the control facilities. Fort Benning instrumentation will be in place for experimentation to commence in the second quarter of FY98; Camp Lejeune instrumentation will be in place for experimentation to commence in the fourth quarter of FY98.
Rapid Terrain Visualization (RTV) **(User sponsors: U.S. Atlantic Command), DTO A.06** *Purpose:* To demonstrate the technologies and infrastructure necessary to rapidly provide digital topographic data (DTD). Future conflicts will likely involve U.S. forces in regions lacking topographic data, where indigenous forces will have the most comprehensive and accurate knowledge of the terrain. This terrain knowledge will greatly benefit the enemy and allow him to better control the battlefield to suit his tactical objectives. U.S. forces require timely and comprehensive DTD to counter this disparity. In FY97, a baseline testbed was established at Ft. Bragg, and selected capabilities were integrated and tested as part of warfighter exercises. This testbed established a fundamental terrain visualization infrastructure, facilitated user training, and provided feedback on requirements. Twelve warfighter exercises have been supported to date using this testbed.
Adaptive Course of Action (ACOA) **(User Sponsors: U.S. Atlantic Command, U.S. Pacific Command)** *Purpose:* To demonstrate technology enablers to permit a change in joint planning and execution from a data-driven to an event-driven process, adaptive to rapidly changing situations, alternative execution options, and number of personnel on scene. ACOA handling will be achieved by (1) enhancing the operational picture to include focused information about alternative situations and execution options relative to the current plan; (2) providing automated management to keep track of several alternative COAs with checkpoints in the planning process to prevent planners from getting ahead of decision makers; (3) providing real-time reachback to experts and high-fidelity COA assessment; and (4) providing plan consistency throughout the Joint Planning and Execution Community (JPEC).
C^4I for Coalition Warfare **(User Sponsor: U.S. European Command), DTO A.23** *Purpose:* To develop a modular software package that will allow internationally standardized messages and replicated data to be passed between U.S. Army C^2 systems and those of allied countries. Information will cover situational awareness data, plans and orders, and battlefield control features data. The C^2SIP capability will be incrementally fielded into the Army's Maneuver Control System (MCS) over a 5-year period. C^2SIP will exploit the work already carried out internationally in the Battlefield Interoperability Program (BIP), Quadrilateral Interoperability Program (QIP), and Army Tactical Command and Control Information System (ATCCIS) initiatives. The armies from Canada, France, Germany, Italy, and the United Kingdom are all involved in various aspects of the work and will field the various parts of the capability according to their own national system development plans.
High-Power Microwave (HPM) **(User Sponsor: U.S. European Command), DTO H.11** *Purpose:* To develop and demonstrate HPM technology to disrupt, degrade, or destroy electronics in specific information operations scenarios. In conjunction with development of a CONOPS, a microwave system will be integrated into a suitable delivery platform and transported to a realistic site for demonstration of capabilities. Following the successful technology development test that was completed in FY 97, the HPM system will be reengineered into a fieldable configuration for use by operational personnel in August 1998.

***Information Assurance: Automated Intrusion Detection Environment (AI:AIDE)* (User Sponsor: U.S. Strategic Command), DTO A.26**

Purpose: To create an architecture for the sharing, integration, and analysis of information warfare (IW) attacks. This architecture will incorporate current and maturing intrusion sensing tools in conjunction with expert systems technology for the management of complex distributed systems. IA:AIDE will correlate intrusion events at local agency, CINC, and joint command levels to tighten the detection grid and increase the success of identifying the IW threats. It will allow local agencies to improve their security posture, permit regional commands to identify distributed attacks, provide a large view of the threat to DoD-wide systems, and allow for a global response to an IW threat by sharing information with appropriate military, law enforcement, intelligence, or operations agencies. FY 98 ACTD efforts will focus primarily on integration of multiple sensors and display (visualization) of the associated data.

***Joint Biological Remote Early Warning System (JBREWS)* (User Sponsor: U.S. European Command), DTO I.02**

Purpose: To evaluate the military utility of a biological early warning capability that allows an increased decision cycle to warn, report, and protect deployed forces. The ACTD provides the sponsoring CINC an interim, transportable capability to detect and warn forces that may have been exposed to biological warfare (BW) agents, and support that capability for 2 years. Additionally, the ACTD will demonstrate the C^2 interoperability and connectivity necessary to perform automated warning and reporting of a biological attack against a maneuver force. The JBREWS ACTD will provide the first joint service capability for biological remote early warning across the battlespace. Initial deployment of the sensor network will begin in late 1999 in the EUCOM area of operations.

***Joint Continuous-Strike Environment (JCSE)* (User Sponsor: U.S. European Command), DTO B.07**

Purpose: To develop and demonstrate software that will augment and advance service, joint, and combined fire support systems. During the course of the ACTD, JCSE functionality will be demonstrated in a series of joint and combined exercises employing deep-strike assets from all services and selected allied assets against time-sensitive surface targets (TSSTs), which are defined as high-payoff vehicles, force groupings, and fixed-facility complexes that must be attacked inside cycle times. Cycle times are consistently achievable through the current Joint Targeting Process. JCSE will take advantage of existing but untapped potential for servicing TSSTs to shunt and accelerate information along the sensor-to-shooter pathways, enabling a Joint Force Commander (JFC) to hold TSSTs at risk without disrupting other aspects of his campaign plan. JCSE provides four capabilities: (1) automated target prioritization, (2) continuous weapon availability monitoring, (3) optimized weapon target pairing, and (4) near-real-time airspace deconfliction.

***Joint Modular Lighterage System (JMLS)* (Users Sponsor: N/A), DTO F.20**

Purpose: To demonstrate a service-interoperable prototype causeway lighterage system to safely assemble and operate (in a loaded condition) through sea state 3 (SS3). This capability will permit the rapid planning, deployment, and execution of more responsive and efficient logistics support of amphibious operations in SS3 conditions. The JMLS ACTD exploits emerging technologies to provide a fully capable SS3 causeway system. By leveraging government and industry research and development, recent technological advances now permit the integration of high-sea-state connector systems, composite materials and fabrication methods, and new system employment capabilities. In January 1998, the process began to issue requests for proposals to industry and award contracts for integrated design and development of the JMLS causeway system. In FY99, testing and evaluation will be conducted at the component and system levels, and fleet- and joint-level exercises will be conducted to demonstrate successful SS3 LOTS/JLOTS causeway system assembly and operations.

Line-of-Sight Antitank System (LOSAT) **(User Sponsor: U.S. Central Command), DTO M.04**

Purpose: To meet the requirements of the airborne forces, the LOSAT weapon system, with the overwhelming lethality of the kinetic energy missile, will be integrated into an expanded-capacity High-Mobility Multipurpose Wheeled Vehicle (HMMWV) to meet C–130 airdrop requirements and UH–60L (Blackhawk) helicopter slingload weight constraints. In addition to undergoing repackaging to make the system compatible with the HMMWV, the system design must meet Army safety and man-rating requirements before being released for the user evaluations. The user will experiment with the system in three major Dismounted Battlespace Battle Lab Warfighting Experiments, beginning in FY 02, to demonstrate the deployability, lethality, and survivability of the system, and its impact on the early entry forces. After successful demonstrations, the end result of the ACTD will be an interim capability in FY 03, for the XVIII Airborne Corps, of a LOSAT company composed of 12 fire units and the associated basic load of kinetic energy missiles.

Link–16 **(User Sponsor: U.S. Atlantic Command), DTO C.07**

Purpose: To demonstrate a joint integrated capability to pass real-time tactical information seamlessly between L–16 and Joint Variable Message Format (JVMF) networks. Link–16 will improve situational awareness in the battlespace and reduce task loads, while providing a conduit for target identification, thereby reducing fratricide. The overall intent is to demonstrate the efficacy of emerging capabilities to provide significant increases in timely delivery of crucial battlefield information. Specifically, this ACTD will demonstrate J-series family tactical datalink (TDL) digitized battlespace interoperability by developing transportable software to exchange tactical information to and from L–16 and VMF networks. Initial planning began in FY 97 and will continue for up to 24 months. A workup field test (DT) and operational demonstration are planned for FY 99.

Migration Defense Intelligence Threat Data System (MDITDS) **(User Sponsor: U.S. European Command)**

Purpose: To supply the information infrastructure required for day-to-day situation awareness intelligence in support of Combating Terrorism (CT) and Force Protection (FP) operations. The ACTD will upgrade MDITDS software with advanced applications to maintain on line a "virtual" centralized database of all antiterrorism security assessments and inspections of DoD facilities, as well as provide analysis on CT policy and the threat worldwide to DoD interests. MDITDS will provide the data repository and the vehicles to access, evaluate, and disseminate this information. The MDITDS is a 5-year program running from FY 98 through FY 02.

Precision Targeting Identification (PTID) **(User Sponsor: Joint Interagency Task Force East), DTO C.05**

Purpose: To demonstrate the military worth of an advanced, cost-effective surveillance and target identification technology in an operational environment. The ACTD will employ an advanced, third-generation infrared sensor and laser radar (LADAR) system. The PTID system will provide a day/night target detection, classification, and dissemination capability at standoff ranges that cannot be achieved with conventional detection and monitoring systems. The initial operational capability of the PTID will set the stage for the rapid transition into engineering and manufacturing development and acquisition for surveillance and tactical platforms.

Space-Based Space Surveillance Operations (SBSSO) **(User Sponsor: U.S. Space Command)**

Purpose: To demonstrate end-to-end space-based space surveillance; develop the associated tasking, scheduling, and formatting procedures; and determine the overall operational utility of space-based sensors compared with ground-based sensors. The SBSSO ACTD is a follow-on to the BMDO Midcourse Space Experiment (MSX) program using the spacecraft's space-based visible (SBV) sensor. SBSSO will provide a space-based space surveillance capability for the first time. Scheduled for 36 months (FY 98–FY 00), the ACTD effects the transition of MSX/SBV operations to contributing sensor status for U.S. Space Command's space control operations in FY 98. The program is inexpensive because it utilizes an existing on-orbit spacecraft and contracted support. Additionally, the SBSSO ACTD serves as a testbed for future space-based space surveillance operations requirements in the Space-Based Infrared System (SBIRS) low-post demonstration/validation and objective system spacecraft.

***Theater Precision Strike Operations (TPSO)* (User Sponsor: U.S. Forces Korea), DTO B.25**

Purpose: To provide the CINC with a significantly improved capability to plan and direct theater counterfire and precision strike operations through the real-time synchronization of U.S./coalition assets. TPSO addresses this urgent need by applying mature technologies to enhance the joint and combined C^4I and strike planning processes at the theater level. Attaining this objective will permit the commander to see the battle, focus warfighting assets to shape the battlefield, and influence the outcome to achieve the objectives. Enabling objectives of the TPSO ACTD are (1) to enhance the C^4I strike planning process, (2) to enhance joint and combined interoperability, (3) to enhance transition to reinforcement, and (4) to provide a venue to demonstrate integration of externally funded weapon systems and JTTPs. A series of three annual demonstrations will begin in FY99 and will be completed by FY01. The final 2 years (2002 to 2003) will focus on support and sustainment of the interim capability.

***Unattended Ground Sensors (UGS)* (User Sponsors: U.S. Central Command, U.S. Southern Command), DTO A.24**

Purpose: To develop and demonstrate two families of leave-behind ground sensors that are hand emplaced or air delivered and support the mission requirements for reporting either movement of time-critical targets or accurate and local weather conditions. The UGS ACTD addresses the complete end-to-end operation of these systems, to include planning tools for emplacement, hand and air delivery methods, sensing and data processing, reporting via satellite communications, and data dissemination through existing networks to decision makers. UGS will greatly enhance the capability to monitor the battlespace on a continuous basis, tip off other collection systems, and make timely decisions based on sensor reports. The UGS ACTD is a follow-on to two distinct sensor programs: (1) the Central Measurement and Signatures Intelligence (MASINT) Office Unattended MASINT Sensor (UMS) program and (2) USSOCOM's Remote Miniature Weather Station (RMWS) program. Under the UMS program, Sandia National Laboratories developed and tested an acoustic/seismic prototype sensor capable of identifying and reporting TCTs. The hand-emplaced sensor was demonstrated during the Roving Sands 97 Exercise, and the air-delivered sensor is currently being tested for release from aircraft. Under the RMWS program, hand-emplaced and air-delivered sensors have been developed. Testing is underway and will continue throughout FY 98 with a full system demonstration planned for FY 99.

COMPLETED ACTDs

***KE Boost-Phase Intercept (Phase I)* (User sponsors: Air Combat Command, and Naval Air Warfare Center (N–88), Deputy Chief of Naval Operations for Resources & Warfare Requirements)**

Purpose: To assess the operational utility, mission effectiveness, and affordability of air-launched kinetic-energy, boost-phase intercept (BPI) systems. This ACTD was terminated after the completion of Phase I. A concept of operations (CONOPS) review indicated that the kinetic kill BPI concept was technically feasible but too asset intensive. Based on the results of Phase I, the decision was made not to proceed with the KE BPI Phase II ACTD, which would have fabricated and demonstrated the capability.

***Cruise Missile Defense—Phase I* (User sponsor: U.S. Pacific Command)**

Purpose: To detect, track, and successfully engage cruise missiles at ranges beyond the radar horizon of ship- and land-based air defense units, and to assess joint doctrine and concepts of air defense operations. Radars on a mountaintop site (simulating airborne radars) were used to detect and track missiles that would have been beyond line-of-sight for surface-based sensors. Engagement data were transmitted to interceptor missiles, and successful live-fire engagements with SM–2s and over 100 simulated intercepts with Patriot PAC–3 seekers were demonstrated. This ACTD validated the Air-Directed Surface-to-Air Missile (ADSAM) concept—the key to engaging cruise missiles at over-the-horizon ranges from surface-based air defense units.

Medium-Altitude Endurance Unmanned Aerial Vehicle (MAE) (Predator) **(User sponsor: U.S. Atlantic Command)**

Purpose: To provide a rapidly deployable, medium-altitude reconnaissance and surveillance capability. Predator progressed from a concept to a three-system operational capability in less than 30 months. The Predator ACTD was initiated in 1993, and the first flight occurred in 1994. Predator first deployed to Gjader Field, Albania, from June to October 1995 in support of Operation Provide Promise, flying 77 operational missions and logging 753 hours. Since March 1996, it has flown 319 operational flights totaling 2,747 hours from Taszar, Hungary, in support of IFOR/SFOR tasking. Overall, Predator has logged 1,597 flights totaling 7,176 hours. This ACTD is complete; operational lead and program acquisition have undergone transition to the Air Force.

Precision-Rapid Counter Multiple Rocket Launcher **(User sponsor: U.S. Forces Korea)**

Purpose: To develop and demonstrate an adverse-weather, day/night, end-to-end, sensor-to-shooter, precision deep-strike capability against North Korean long-range artillery. Two demonstrations were conducted—one based at Fort Hood, Texas, and the other at Camp Red Cloud in Korea—involving both live and simulated forces. Command and control (C^2) links in Korea were upgraded. The Navy and Air Force participated in the Joint Fire Support Interoperability demonstration. The major demonstration in Korea was the successful culmination of the development and installation phase of the ACTD. The leave-behind equipment installed in Korea will be supported by the ACTD team for the 2-year leave-behind period. The ACTD has greatly increased the ability of the 2nd Infantry Division to deal with the threat of long-range artillery from the north.

Low-Life-Cycle Cost, Medium-Lift Helicopter **(User sponsors: Navy, Military Sealift Command)**

Purpose: To evaluate the military utility of employing a commercial-off-the-shelf helicopter to perform the Military Sealift Command fleet vertical lift support mission. This ACTD, originally planned for FY96, was executed during August–October 1995 with a very successful demonstration of leased commercial helicopters and crews on Military Sealift Command ships. As a result of the demonstration, the Navy has concluded that leasing helicopters may be a viable alternative for vertical replenishment. The Navy completed a 6-month follow-on demonstration in the Indian Ocean in December 1996 and is considering privatization options for the rest of the Military Sealift Command fleet.

Counter-Sniper **(User sponsor: Dismounted Battlespace Battle Laboratory)**

Purpose: To rapidly provide counter-sniper sensor systems for evaluation by Army, Marine, and Special Forces users; provide training for users who will be prepared to quickly deploy sniper detection technology; and provide feedback to system developers. This 3-month ACTD was completed in October 1996. The sensors were delivered to the Dismounted Battlespace Battle Laboratory. Training, testing, and doctrine development are ongoing. The sensors and trained soldiers/marines are available for contingencies.

C. JOINT WARFIGHTING EXPERIMENTATION

Joint Warfighting Experimentation is an iterative process to examine innovative approaches to joint-force full-spectrum dominance. Carefully formulated hyphotheses of joint warfighting operational concepts are examined empirically employing constructive, virtual and live simulations, often embedded in joint-force exercises. The hypotheses suggest how new operational concepts for doctrine, organization, training, leadership, and modernization can co-evolve to major improvements in future joint warfighting capabilities. Joint Warfighting Experiments (JWEs) are DoD-wide efforts that include Service Warfighting Experiments (SWEs) and the integration of ACTDs, ATDs, developmental and fielded systems, and emerging commercial systems and capabilities. The notional components of a JWE are illustrated in Figure III–1.

An important emerging area of focus for JWEs is Information Superiority. JWEs are envisioned that are specifically focused on the operational capabilities associated with Information

Superiority. These JWEs will provide valuable feedback to the Joint Warfighter on the significant operational benefits of Information Superiority. The aggressive implementation of JWEs is required to pace the co-evolution of organization, technology, doctrine, and system of the Joint Warfighting Concepts of JV 2010: Dominant Maneuver, Precision Engagement, Focused Logistics, and Full-Dimensional Protection.

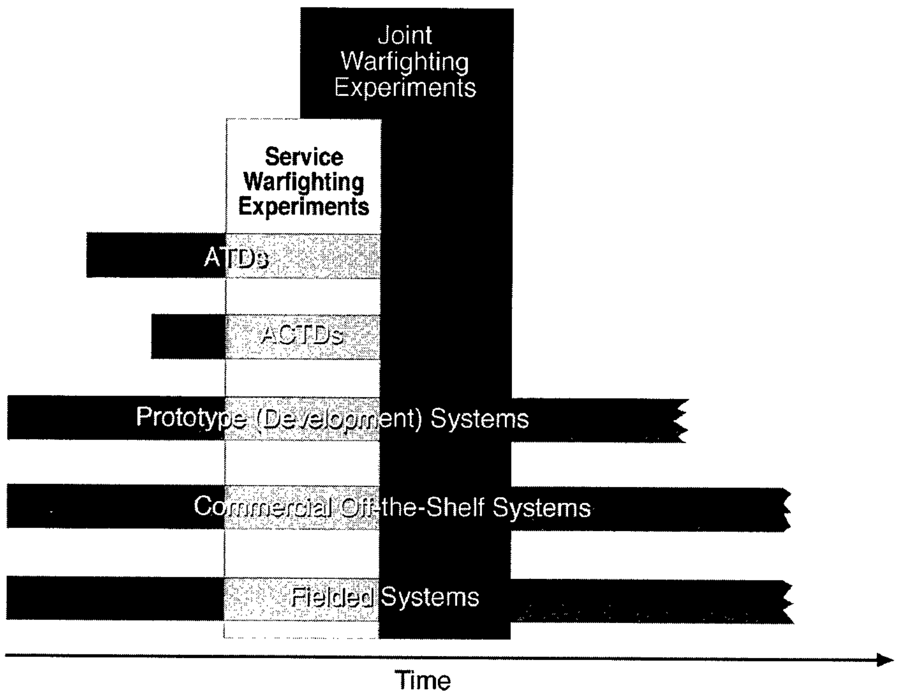


Figure III–1. Notional Building Blocks of a Joint Warfighting Experiment

CHAPTER IV

INFORMATION SUPERIORITY

CHAPTER IV
INFORMATION SUPERIORITY

A. DEFINITION

Information Superiority (IS) is defined by the Joint Chiefs of Staff (JCS) as the "degree of dominance in the information domain that permits the conduct of operations without effective opposition" (Reference 10). To ensure that our forces can acquire, verify, protect and assimilate the information needed to effectively neutralize and dominate adversary forces, IS must combine the capabilities of command, control, communications and computers (C^4); intelligence, surveillance, and reconnaissance (ISR); and information warfare (IW).

Command and control (C^2) is defined as the "exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission" (Reference 11). The C^2 process involves gathering information, assessing the situation, identifying objectives, developing alternative courses of action, deciding on a course of action, transmitting orders that can be understood by recipients, and monitoring execution (Reference 12). This requires maintaining a seamless, robust network linking all friendly forces and providing common awareness of the current situation (C^4). The ISR component of IS provides near-real-time awareness of the location and activity of friendly, adversary, and neutral forces throughout the battlespace. For the purposes of this document, C^4 and ISR will be referred to collectively as C^4ISR. The IW component discussed in this chapter deals with the capability to defend one's own information, information-based processes, information systems, and computer-based networks against outside infiltration and manipulation.

The term *information system* includes information, information-based processes, information hardware and software systems, and computer-based networks either individually or in combination with each other. It should be noted that information superiority is a dynamic area. Doctrine, policy, and taxonomy must evolve as quickly as the supporting technology. The taxonomy describes the relevance of key technology initiatives to joint warfighter requirements, but is not representative of the entire spectrum of warfighter IS roles and missions. Exactly how these initiatives are described will continue to evolve.

Information Superiority is essential to achieving virtually all other joint warfighting capabilities in the 21st century battlespace. U.S. information superiority also requires an ability to protect the information collection, processing, and dissemination capabilities of the United States and its coalition partners. The majority of the IS S&T progress is being achieved in the commercial sector. These advancements are being made available to friends and foes alike at lightning speed. It will be the U.S. DoD S&T policy to ensure that all military systems have sufficient open architectures to facilitate adding the latest technology as it becomes available.

B. OPERATIONAL CAPABILITY ELEMENTS

Warfighters of the future must be able to respond rapidly and effectively, with little or no tactical warning, to a wide range of uncertain threats. These threats include conventional forces, weapons of mass destruction (WMD) of increasing technological sophistication, and many other adversarial forces of increasing capability. At the same time, there is a decreasing likelihood of the presence of forward-based U.S. forces in a theater of action. An effective U.S. response is likely to require interoperation and sharing of resources with other coalition forces in the face of these threats. The Chairman of the Joint Chiefs of Staff's *Joint Vision 2010* calls for the rapid deployment of forces capable of engaging an enemy on arrival and sustaining operations with a minimal logistics tail in the area of operations, as well as the immediate execution of noncombat missions.

Achieving this capability demands significant advances in our ability to deliver the right data and information at the right time to commanders at all levels, to use that data and information to develop superior knowledge of the battlespace in real time, and to employ that knowledge effectively in planning and executing operations. To achieve and maintain force dominance in the 21st century, the emphasis on information technology development must shift from a platform-centric to a network-centric approach. The shift to an open-architecture, network-centric focus will allow the joint warfighter to achieve greater agility in responding to changes in threat and exploiting continuing advances in technology.

The goal of IS, as illustrated in Figure IV–1, is to enable the development of new concepts of operation that will ensure operational dominance of the battlespace. This is accomplished by blending three broad areas of operational capabilities—battlespace awareness, effective force employment, and an integrated grid of assured services, referred to simply as the C^4ISR grid—into an overall federated system. These capabilities are significantly more advanced than the initial capabilities of the Global Command and Control System (GCCS) and those recently successfully demonstrated in the Bosnia Command and Control Augmentation (BC^2A) program. Initial segments of these capabilities will be demonstrated in DARPA's Information Superiority Demonstration 98 and 99.

The Advanced Battlespace Information System (ABIS) study defined three operational capability elements within each of the three broad operational capability areas (Reference 13):

- *Battlespace awareness—information acquisition, precision information direction,* and *consistent battlespace understanding.* These capabilities allow the joint warfighter to control and shape the pace of the battle by providing commanders with a broader perspective and better intuitive feel of the battlespace, including the environmental conditions and operational situation.

- *Effective employment of forces—predictive planning and preemption, integrated force management,* and *execution of time-critical missions.* These capabilities allow the joint warfighter to plan and execute operations in a manner that achieves an overwhelming effect at precise places and times.

- *C^4ISR Grid (composed of Sensor Grid, Information Grid, and Engagement Grid)—universal transaction services, distributed environment support,* and *high assurance of services.* These capabilities allow the joint warfighter to rapidly adapt to changing situations

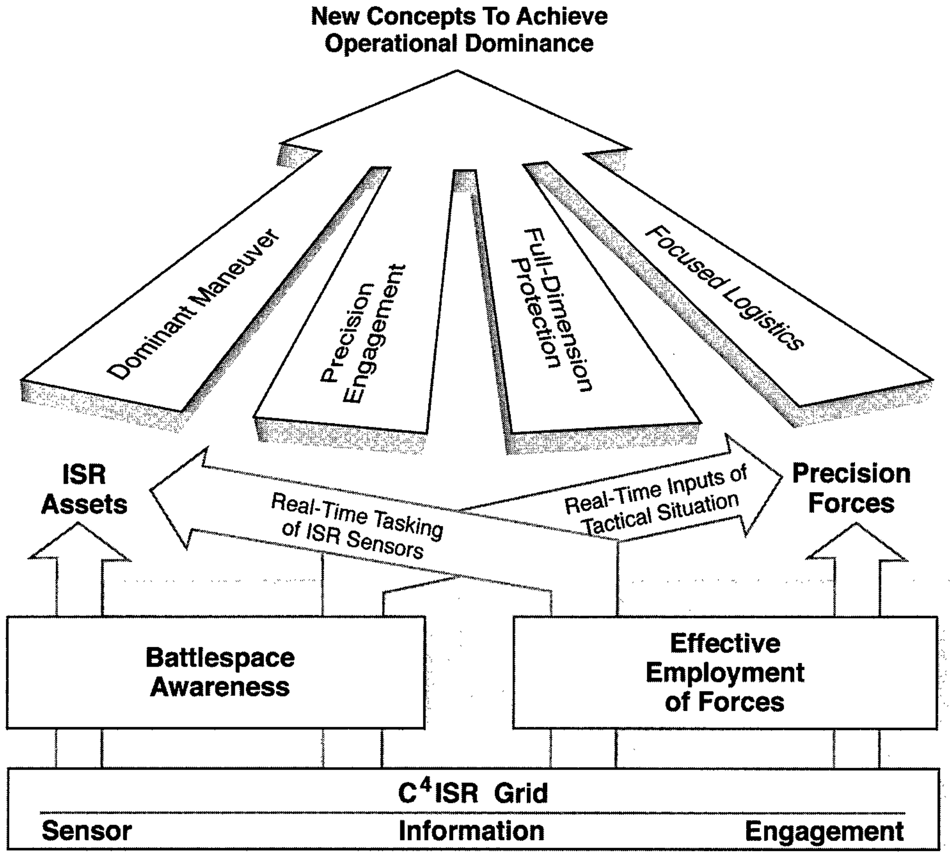


Figure IV–1. Concept—Information Superiority

and environmental conditions and to attack high-priority targets throughout the battlespace. Information superiority empowers lower echelon force elements by widely distributing the commander's intent and the information needed for timely and effective execution. Because these capabilities inevitably degrade in the course of battle, a key objective of IS is to enable commanders to plan for this eventuality, to identify and protect essential capabilities, and to reconfigure information flows and supporting C^2 structures to meet changing needs. This high degree of flexibility is achieved by a network-centric approach to the integration of current and future sensor, information, and engagement grids into a single C^4ISR grid.

As a part of the ABIS operational capabilities, the joint warfighter must have a superior IW operational capability to defend information systems from both deliberate and accidental disruptions, intrusions, manipulations, and corruptions. This gives the joint warfighter a credible deterrent across the full spectrum of conflict, ensures information superiority, and permits the conduct of operations without effective opposition. Figure IV–2 represents a conceptual view of the IW environment. This operational capability is of increasing importance as information technology becomes more widely available throughout the world.

The IW technology base must support joint warfighter requirements in both defensive information warfare (IW–D) and effective management of the sensor, information, and engagement grids

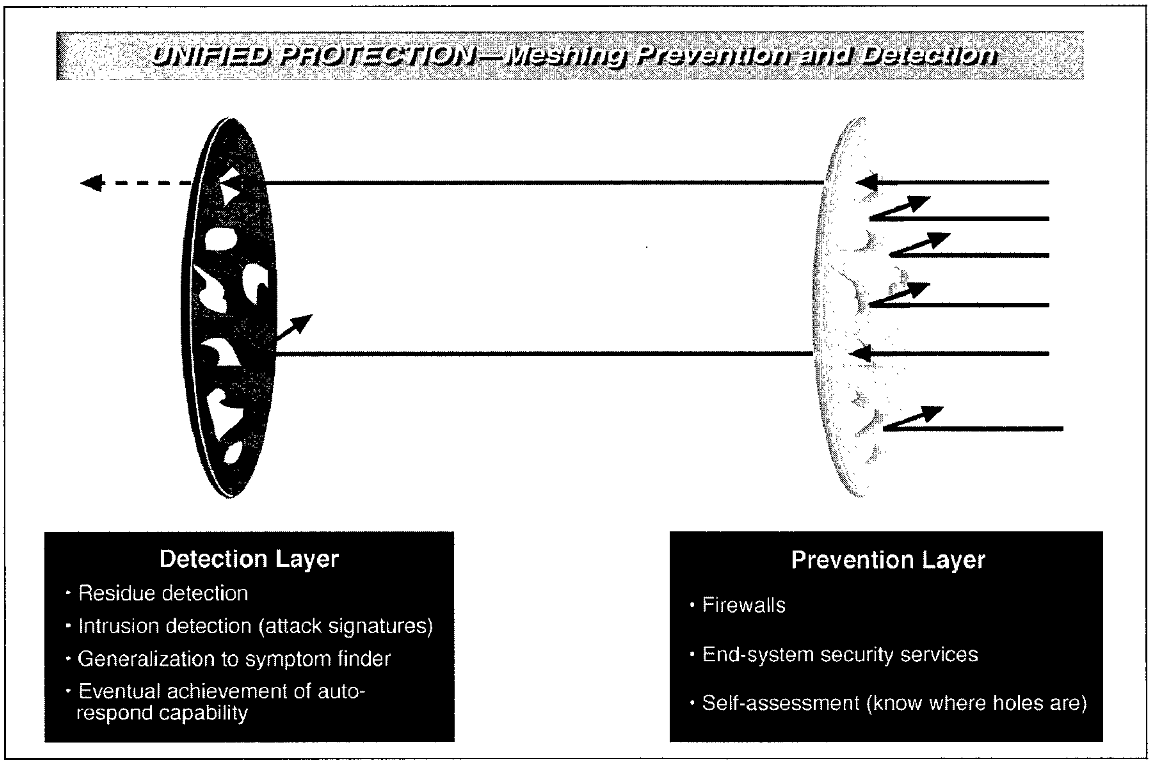


Figure IV–2. Concept—Information Warfare

that compose the C⁴ISR grid. IW–D operational capabilities include information security, operations security, information integrity, attack detection, and restoration.

As in the ABIS study, critical IW–D operational capabilities are included under assurance of services as part of the C⁴ISR grid. Effective C⁴I has been integrated into various other capability areas as appropriate.

Battlespace Awareness. Battlespace awareness includes the operational capability to acquire and assimilate information about the position and movement of friendly, adversary, and neutral forces, and about the geospatial situation (e.g., terrain, weather, space bathymetric conditions) in which they are deployed. It includes the capabilities to provide a common view and understanding of the situation across tactical and supporting forces, from joint force commanders to individual shooters. The effective integration of battlespace awareness within a federated system will provide the warfighter with an extended view of the battlespace and of current and projected operational conditions, and an enhanced ability to identify and localize features of the battlespace in the face of degraded environmental conditions and hostile countermeasures. This extended view will support and enhance the warfighters' intuitive feel for situations and command options.

The specific operational capabilities necessary to achieve battlespace awareness are as follows:

- *Information acquisition*—the provision of sufficient, timely, and high-quality surveillance, reporting, target designation, and assessment information on enemy, friendly, and U.S. units, events, activities, status, capabilities, plans, and intentions to ensure that joint or coalition commanders have dominant battlespace knowledge.

- *Precision information direction*—the capability to dynamically direct and integrate both tactical and supporting C^4 and ISR resources for targeting, weaponeering, mission preview, battle damage assessment (BDA), and combat assessment to maintain the ability for the on-scene commander to exploit and shape the battlespace. This also includes the integration and synchronization of information into up-to-date mission products to be delivered just in time to the warfighter.

- *Consistent battlespace understanding*—the capability to elevate the level and speed of the warfighter's cognitive understanding of enemy, friendly, and geospatial situations, and to maintain consistency in that view across tactical and supporting forces.

Effective Employment of Forces. With information superiority, commanders will be able to exploit their superior understanding of the battlespace to shape and control the conflict. Specific operational capability elements are as follows:

- *Predictive planning and preemption*—the ability to be proactive in the planning process in order to avoid direct confrontation (by employing alternative means), to be prepared to react and exploit opportunities when direct confrontation must occur, and to shape expected actions in order to stay within an enemy's decision cycle and keep him out of ours.

- *Integrated force management*—the capabilities needed to achieve the dynamic synchronization of missions and resources from components and coalition forces.

- *Execution of time-critical missions*—the ability to provide processing languages, interface characteristics, and linkages that enable rapid target search and acquisition, battle coordination and target selection, handoff, and engagement for the prosecution of time-critical targets.

The C^4ISR Grid. The C^4ISR grid will support global connectivity with flexible, rapidly configurable network services, automated assistance to facilitate universal user access to information, and assured services in stressed environments. These services will also provide flexible command structures and support for time-critical, short-duration mission tasks such as "sensor-to-shooter" integration and support. The services of the C^4ISR grid are conceptually separate from command structures, disseminating battlespace awareness to users when they need it and in the form that they need it to facilitate the collaborative planning and execution of joint and coalition operations. Achieving connectivity and flexibility across heterogeneous systems will also allow the creation of "virtual staffs" that expand and augment the capabilities of in-theater forces with collaborative services, reach-back capabilities, and reduced local footprint.

The critical operational capabilities of the C^4ISR grid are:

- *Universal transaction services*—the capability to provide warfighters and their systems the ability to exchange and understand information, unimpeded by differences in connectivity and national language, on a "just-in-time" basis, regardless of location.

- *Distributed environment support*—the mechanisms and services required to allow the warfighters to craft their C^4ISR information environments from the full set of assets connected through the C^4ISR grid, including the ability to establish distributed virtual staffs and task teams.

- *High assurance of services*—high-quality services that warfighters must have, when needed, to meet dynamically changing demands and defend against physical and information warfare threats. This includes adaptive network management that anticipates changing requirements, and the defensive IW operational capabilities of information security, operations security, information integrity, attack detection, and restoration. Information security encompasses confidentiality, integrity, authentication, nonrepudiation, and, to some extent, availability. Operations security ensures that critical friendly information and activities cannot be easily intercepted or observed by adversary intelligence systems. Information integrity ensures that the information to support battlefield awareness is unimpaired.

As these advanced concepts are prototyped and demonstrated, they will be candidates for inclusion in a new program element, Joint Warfighting. This program fields emerging concepts and tools on an Information Technology (IT) Backplane to permit live, virtual, and constructive Information Superiority Experiments (ISXs) that will quantify the impact of information to the warfighter. The goal is the co-evolution of technology, organization, and doctrine.

C. FUNCTIONAL CAPABILITIES

Achieving critical IS operational capability elements will require significant advances in numerous functional capabilities to manage the acquisition, simultaneous processing, and parallel dissemination and presentation of information in an assured and secure manner, and to effectively integrate mission planning functions. The complexity of the information must be condensed and synthesized to an understandable level for the joint warfighter. This will require additional R&D in cognitive science and human computer interface to allow the user to comprehend the situation.

Because information superiority has taken on a more global context, capabilities are needed for automated text understanding and foreign language translation of messages and documents. The ever-expanding volume of foreign and domestic message traffic places an additional burden on the systems needed to store, maintain, search, and retrieve data. R&D to advance the engineering of large databases is also needed to improve the capability to manage huge amounts of data. In fact, as the C^4ISR grid continues to evolve into a "system of systems," a focus on total life cycle systems engineering is needed to achieve end-to-end performance.

Table IV–1 provides a mapping of the IS functional capabilities to the operational capability elements and broad operational capabilities.

Table IV–1. Functional Capabilities Needed—Information Superiority

Functional Capabilities	Operational Capability Elements								
	Battlespace Awareness			Effective Employment of Forces			C^{4}ISR Grid		
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services
1. Intelligence Processing and Broadcast	●		○	●	●	●			
2. Intelligent, Distributed Mapping, Charting, and Geodesy (MC&G)	●		●						
3. Collaborative Situation Assessment and BDA			●			●			
4. Collection and Distribution of Weather and Environmental Conditions			●	●					
5. Common Understanding and Representation of the Battlespace			●	●					
6. Consistent Situation Projection		●	●	●					
7. Mission Rehearsal and Embedded Training		●			●				
8. Command Projection and Sharing of Commander's Intent		●		●	●				
9. Support for Simultaneous, Coordinated Operation					●				
10. Repair and Consumables Management	○		○	●	●	●	●		○
11. Joint Force Automated Battle Rules of Engagement					●				
12. Theater Intelligence Processing and Broadcast	●		●						
13. Shared, Distributed Collaborative Planning		●		●	●	●			
14. Rapid, Accurate Battle Damage Assessment (BDA)		●				●			
15. C^{4}ISR System Management	●				●	●			
16. Force Status and Execution Management					●	●			
17. Parallel Dissemination of Intelligence/BDA						●			
18. Rapid, Accurate Automated Targeting	○	●	●		●	●			
19. Automated Mission and Weapon-to-Target Pairing						●			
20. Seamless Connectivity							●		
21. Space Assets	●	●	●	●	●	●	●	●	●
22. Automatic Adaptive Information Conditioning							●		
23. Location-Independent Addressing, Both Stationary and "On the Move"							●		
24. Flexible, Adaptive Access Control							●		
25. Support for Heterogeneous Users and Interfaces								●	

● Strong Support ○ Moderate Support

Table IV–1. Functional Capabilities Needed—Information Superiority (continued)

	Operational Capability Elements								
	Battlespace Awareness			Effective Employment of Forces			C^4ISR Grid		
Functional Capabilities	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services
26. Knowledge-Based Access, Retrieval, and Integration of Information								●	
27. Distributed, Collaborative Processing								●	
28. Massive, Heterogeneous Distributed Information Management								●	
29. Automated Intelligent C^4ISR Grid System Management									●
30. Service Extension and Modular "Plug and Play"									●
31. Information Consistency, Integrity, Protection, and Authentication									●
32. Access Controls/Security Services									●
33. Service Availability							●		●
34. Network Management and Control							●		●
35. Damage Assessment							●		●
36. Reaction (Isolate, Correct, Act), Including Recovery and Reconstitution									●
37. Vulnerability Assessment and Planning							●		●
38. Preemptive Indication									●
39. Intrusion Detection/Threat Warning									●
40. IW and Spectrum Dominance Planning and Monitoring		●			●				
41. Synthesis of Complex Data and Information			●		●				
42. Large Database Engineering, Manipulation, Search, and Retrieval	●		●		●		●		
43. Realistic C^4ISR Modeling and Simulation				●					
44. Text Understanding	●		●						
45. Foreign Language Translation	●		●						
46. Life Cycle Systems Engineering									●

● Strong Support ○ Moderate Support

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

Currently fielded information systems do not support the kind of robust, assured, and timely flow of accurate and relevant information needed to meet future joint warfighting needs. Operational practices limit flexibility and effective employment, even though ongoing DoD and individual service efforts such as the Defense Information Infrastructure (DII, part of the National Information Infrastructure) and C^4ISR Integration Task Force are making important improvements.

The structure for C^4ISR remains divided along organizational and functional lines and is strongly tied to the hierarchical command structure, due in large part to inadequate capabilities for the automation of multilevel security. Users must know the secure network addresses of all the nodes with which they want to communicate—a daunting requirement in the heat of battle. Even when information can be provided, it may be in a form that has been tailored and optimized for some other mission. These divisions, tied to a rigid framework of battlefield geometry, limit a commander's ability to assign sensors to priority targets and to dynamically retask high-value assets across missions and services in response to changing situations and opportunities. Furthermore, communications bandwidths and connectivity are inadequate to support the flow of data under conditions of peak demand.

"Stovepiping"—the operational fragmentation and end-to-end segregation of information flow by type, command structure, and mission—makes it difficult to acquire, process, and disseminate essential information across joint forces, and makes it virtually impossible to develop a common picture of the battlespace. The ever-increasing amount of foreign language message traffic further exacerbates this problem. In addition, the sheer volume and complexity of information are often overwhelming. Although there is a high degree of assurance (i.e., confidence in the integrity, confidentiality, and availability) associated with information received via stovepiped classified systems, there is less assurance associated with information received across heterogeneous systems.

Current C^4ISR systems provide only a limited ability to detect and monitor targets and events concealed in foliage, in structures, under ground, or in adverse weather or countermeasure environments. Rigid ISR systems and lack of visibility of independent tactical sensor tasking and coverage further limit our ability to manage and coordinate sensor assets for real-time operations.

IW–D limitations include:

- Inadequate management of distributed information
- Lack of flexible high-assurance systems with multiple levels of security and multilevel security (MLS) that facilitate interoperability
- Countermeasures that are generally reactive to emergent IW rather than anticipatory
- Lack of predictive and anticipatory network management capabilities
- Limited IW sensors and processing capability for C^4ISR grid self-defense
- Intrusion detection techniques that do not scale or that do not facilitate damage assessment or automated response.

A number of technological, organizational, operational, and programmatic barriers make it difficult to overcome these limitations. Nonetheless, existing capabilities are being applied in unique

ways and are being extended to provide more effective means of network protection. Ranging from advanced access control systems to effective means of encryption of databases and transmitted information, tools are becoming available that help ensure the availability, integrity, and confidentiality of critical information for the joint warfighter.

Technological advances alone are not sufficient. Traditional concepts of operation and rigid C^{4}ISR structures will need to change if the warfighter is to realize the benefits of advancing technology. Total life cycle systems engineering concepts must be developed and applied to achieve true "plug and play" integration of complex heterogeneous systems and protocols. Battlespace awareness transcends individual service and organizational divisions and will require the effective integration of, and sustained commitment to, individual service and joint programs within a common architecture.

Table IV–2 provides a mapping of key technologies to limitations to functional and operational capabilities.

Table IV–2. Goals, Limitations, and Technologies—Information Superiority

Goal	Functional Capabilities	Limitations	Key Technologies
Battlespace Awareness			
Operational Capability Element: Information Acquisition			
Provide sufficient timely high-quality surveillance, reporting, target designation and assessment information on enemy, friendly, U.S. units, events, activities, status, capabilities, plans/intentions to ensure that joint/coalition commanders have dominant battlespace knowledge.	Intelligence processing and broadcast Intelligent, distributed MC&G Repair and consumables management Theater intelligence processing and broadcast C^{4}ISR system management Rapid accurate automated targeting Large database engineering, manipulation, search, and retrieval Text understanding Foreign language translation Space assets	Limited coverage extent, quality, and continuity currency "Stovepipe" nature of systems/information by type, acquirer/dissemination Few systems have near-real-time capabilities for responding to tasking and providing direct-continuing support to forces Limited capability to detect, identify, and monitor targets/events in foliage, buildings, and underground Many capabilities can be denied by weather and countermeasures Manpower intensive—little automation of integration/fusion, target detection, target ID, and BDA capabilities Manpower intensive language and protocol translation Limited ability to rapidly store, search, and retrieve large volumes of sensor data	Small volume/weight, very high speed capacity processors and storage devices; application software that can be embedded with sensors/platforms Software applications for automated selection and following of coverage areas/targets Software applications for use with multiple data sources (including reference/databases) to enhance target detection, tracking, and designation (e.g., detecting changes) Foliage penetrating moving target indicators (MTI) and synthetic aperture radar (SAR) Near-simultaneous multispectral coverage Passive/multistatic MTI/SAR Small volume/weight, multispectral, rapidly deployable smart surface sensors Direct integration of Global Positioning Systems (GPS) with sensor outputs where appropriate Transfer/translation applications and storage devices/communications for near-real-time tactical aircraft sensors

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Battlespace Awareness (continued)			
Operational Capability Element: Precision Information Direction			
Maintain the ability of the on-scene commander to exploit and shape the battlespace by dynamically directing and integrating (in accordance with operation, battle, and mission priorities) both tactical and supporting ISR resources for targeting, weaponeering, mission preview, BDA, and combat assessment.	Situation projection Mission rehearsal and embedded training Command projection Shared, distributed collaborative planning Rapid, accurate battle damage assessment Rapid accurate automated targeting IW and spectrum dominance planning and monitoring Space assets	Limited response to battlespace changes; rigid ISR, lack of visibility into sensor tasking and coverage Sortie impact limitations, poor/slow BDA Limited comprehensive sensor tasking to support mission No just-in-time retargeting capability	Object-oriented, distributed, automated, and dynamic planning, scheduling, and target handoff Embedded, fault-tolerant, distributed modeling and simulation (M&S) for mission preview, rehearsal, and training M&S for spectrum dominance planning M&S for IW surveillance and planning Joint multisensor fusion, information fusion, and sensor cross-cueing Integrated cross-sensor tracking with unique target ID and real-time updates Automated target and infrastructure identification, recognition, behavior, and change detection and BDA Distributed, collaborative virtual planning in real time Rapid M&S for sensor coverage analysis

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Battlespace Awareness (continued)			
Operational Capability Element: Consistent Battlespace Understanding			
Elevate the level of our cognitive understanding of the enemy, friendly, and geospatial situation; maintain consistency in that view across tactical and supporting forces.	Intelligence processing and broadcast (from CONUS; fused near-real-time (NRT) signals intelligence (SIGINT) and imagery; increased/ fused sensor data in NRT) Intelligent, distributed MC&G Collaborative situation assessment and BDA Collection and distribution of weather and environmental conditions Common understanding and representation of the battlespace Situation projection Repair and consumables management Theater intelligence processing and broadcast Rapid, accurate automated targeting Synthesis of complex data and information Large database engineering, manipulation, search, and retrieval Text understanding Foreign language translation Space assets	No common operational picture Inadequate information support for commander's decision needs Presently too much information without quality thresholds; not scaleable Text message intensive with no automated machine understanding Inadequate dissemination of understanding Intelligence preparation of the battlefield (IPB) of battlespace degrades when battle begins Inability to process multiple languages and protocols	Joint multisensor fusion, information fusion, and sensor cross-cueing Mass storage of information Intelligent products to support decision making Common integrated situation display with selectable detail and resolution High-rate broadcast Automated target and infrastructure identification, recognition, behavior, and change detection and BDA Auto data validation and data validity tags Tailored search and retrieval of information Intelligent agent for knowledge retrieval, filtering, sanitization, and deconfliction Improved data and uncertainty visualization management Real-time M&S for assessment and friendly/enemy course of action (COA) analysis Automated language translation and text understanding Automated language, syntax, and protocol translation Multilevel information security and information assurance Distributed, synchronized, large database

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Effective Employment of Forces			
Operational Capability Element: Predictive Planning and Preemption			
Lean forward in the planning process to (1) avoid direct confrontation (by employing alternatives); (2) be prepared to react and exploit opportunities when direct confrontation must occur; and (3) shape the expected actions to stay within the enemy's decision cycle and keep him out of ours.	Intelligence processing and broadcast Collection and distribution of weather and environmental conditions Common understanding and representation of the battlespace Situation projection Command projection Repair and consumables management Shared, distributed collaborative planning Realistic C^4ISR modeling and simulation Space assets	Automated planning systems not dynamic Wargaming not effectively integrated in C^4ISR and cannot be used for online planning evaluation Sensor tasking and countermeasures are "reactive" to emergent IW rather than anticipatory Information search and retrieval can choke at times of peak demand Lack of distributed, consistent data at all levels	Object-oriented, distributed, automated, and dynamic planning, scheduling, and target handoff Embedded, fault-tolerant, distributed M&S for mission preview, rehearsal, and training M&S for spectrum dominance planning M&S for IW surveillance and planning Automated target and infrastructure identification, recognition, behavior, and change detection and BDA Real-time M&S for assessment and friendly/enemy COA analysis Continuous sliding collaborative planning across battlespace Just-in-time mission package construction and delivery Automated nodal analysis and weaponeering Automated target/weapon pairing and update Easily deployable, evolvable, scaleable, plug-and-play architecture Cross-functional virtual teams
Operational Capability Element: Integrated Force Management			
Achieve dynamic integration of force operations by collaborative execution monitoring, repair, and retasking of shared assets across echelons, missions, components, and coalition forces (control of "coherent" joint/simultaneous operations to optimized dynamic use of resources without preempting "intuitive" use).	Intelligence processing and broadcast Mission rehearsal and embedded training Command projection Support for simultaneous, coordinated operation Repair and consumables management Joint force automated battle doctrine Shared, distributed collaborative planning C^4ISR system management Force status and execution management Rapid accurate automated targeting IW and spectrum dominance planning and monitoring Space assets	Present coordination via rigid framework of battlefield geometry Limited ability to apply all assets to formulate and support coherent defensive situation Limited understanding of what needs to be done (strategy, commander's intent) and relationship of individual tasks to overall campaign objectives Manually intensive development of plans to support simultaneous operations Limited real-time insight into conduct of plan No responsive way to dynamically retask high-value assets across missions and services in response to changing situations and opportunities	Embedded, fault-tolerant, distributed M&S for mission preview, rehearsal, and training M&S for spectrum dominance planning M&S for IW surveillance and planning Real-time M&S for assessment and friendly/enemy COA analysis Automated nodal analysis and weaponeering Distributed, collaborative, and virtual situation awareness Dynamic shared war plan that deals with uncertainty Dynamic allocation of shared resources in real time Decision support to assess and replan consumables

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Effective Employment of Forces (continued)			
Operational Capability Element: Execution of Time-Critical Missions			
Provide a real-time fused battlespace picture with integrated decision aid tools that ensures coordinated dynamic planning and execution of a broad spectrum of missions, from time-phased attack of fixed targets to reconnaissance of battle areas and prosecution of time-critical targets by integrated hunter-controller-killer assets. Provide processing and linkages that enable rapid target search and acquisition, battle coordination and target selection, handoff, and engagement for prosecution of time-critical targets.	Intelligence processing and broadcast Collaborative situation assessment and BDA Repair and consumables management Shared, distributed collaborative planning Rapid, accurate battle damage assessment C^4ISR system management Force status and execution management Parallel dissemination of intelligence/ BDA Rapid, accurate automated targeting Automated mission and weapon to target pairing Space assets	Slow decision and resource allocation process with respect to target cycle times Poor detection of fleeting target entities in crowded battlespace Slow fusion process Best sensor information not incorporated Human-intensive BDA Targets appear after force package commitments, pop-up targets, movement cycles Execution status unknown Inability to counteract target reaction to threat and engagement Simultaneous pulls on sensors Insufficient connectivity Sensor management not tied to commander's intent	Automated nodal analysis and weaponeering Wideband communications and interconnectivity Real-time, cognition aiding displays Automated planning/decision support tools Data interoperability/synchronization Automated IPB process Fusion and integrated target tracking Automatic target recognition Advanced, adaptive, multilevel security ISR management and integration tools
C^4ISR Grid			
Operational Capability Element: Universal Transaction Services			
Provide warfighters and their systems the ability to exchange and understand information, unimpeded by differences in geography, connectivity, processing, language, or interface characteristics on a "just-in-time" basis.	Repair and consumables management Seamless connectivity Automatic adaptive information conditioning Location independent addressing Flexible, adaptive access control Service availability Network management and control Damage assessment Vulnerability assessment and planning Space assets	Information transport generally tied to C^2 hierarchy Lack of interoperability Unacceptable limitations on connectivity to tactical users Lack of adaptive conditioning of information to optimize services Users burdened with requirement to know network addresses Limited ability to support multiple levels of security and multilevel security, especially in coalition operations Limited capability to support continued operations during network partition	Real-time M&S for assessment and friendly/enemy COA analysis Automated nodal analysis and weaponeering Automatic target recognition Advanced, adaptive, multilevel security Adaptable tactical/mobile networking Rapidly deployable tactical fiber extensions Tactically extensible, high-rate, asymmetric mobile communications Advanced compression and coding abstracting for conditioning of information Dynamic reallocation of computing resources MLS secure commercial off-the-shelf (COTS)-based clusters Secure GPS Fault avoidance and recovery mechanisms

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
C^4ISR Grid (continued)			
Operational Capability Element: Distributed Environment Support			
Provide all mechanisms and services required to allow the warfighters to craft their C^4I information environments from the full set of assets connected through the C^4ISR grid, including ability to establish distributed virtual staffs, to share a common consistent perception of the battlespace, and to construct distributed task teams among sensors, shooters, movers, and command posts.	Support for heterogeneous users and interfaces Knowledge-based access, retrieval, and integration of information Distributed, collaborative processing Massive, heterogeneous distributed information management Space assets	Limited ability to integrate processes across heterogeneous system domains Inadequate knowledge of navigation and retrieval for massive, distributed, heterogeneous systems Minimal capability for exploiting information within the network to provide users with knowledge and advisory cues Minimal capability to manage distributed information, especially in asymmetric and broadcast communication environments Limited flexibility and adaptability of information security for coalition operations	Tailored search and retrieval of information Real-time M&S for assessment and friendly/enemy COA analysis Automated nodal analysis and weaponeering Multimode, multilingual interface services Heterogeneous multimedia conferencing Automated mediators and database management system tools Massive data storage and management Flexible information security for information exchange, access, and conferencing
Operational Capability Element: High Assurance of Services			
Provide high-quality services to the warfighters that will be available whenever and wherever needed; that can be adapted, scaled, and projected to meet dynamically changing demands; and that can be defended against physical and information warfare threats.	Automated intelligent C^4ISR system management Service extension Information consistency Life cycle systems engineering Space assets	Limited ability to support multilevel security, especially in coalition operations Lack of modular plug-and-play to allow adaptation of services and to project information-intensive support globally Lack of confidence that nonorganic assets will be available when needed Lack of predictive/anticipatory network management capabilities Lack of IW sensors and processors for C^4ISR grid self-defense Limited ability to provide both capability and "hardness" Limited ability to effect design trades on a system-wide level	Automated nodal analysis and weaponeering Management tools for anticipatory services Tools for projecting and visualizing C^4ISR grid capabilities in terms of projected operational needs Multilevel, adaptive information security IW surveillance and defense tools Software integrity validation Secure distributed systems

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
C⁴ISR Grid (continued)			
Operational Capability Element: High Assurance of Services (continued)			
Provide protection from deliberate or inadvertent unauthorized disclosure, acquisition, manipulation, modification, or loss of sensitive information under various complex security policies, using distributed open systems architectures and different security attributes.	Information consistency Access controls/security services Vulnerability assessment and planning Preemptive indication Intrusion detection/threat warning	Limited ability to support multilevel security, especially in coalition operations Countermeasures generally reactive to emergent IW rather than anticipatory Limited network discovery, management, security management, and expert systems capabilities Limited availability of trusted operating systems Vulnerabilities in application of COTS items Inadequate tools for validating system security and robustness Limited authentication and identification capabilities Inadequate automated intrusion detection techniques Inadequate data contamination recovery techniques	Secure firewalls and guards (B3 Level) Dynamic reallocation of computing resources Automated network discovery, intrusion detection, and response capabilities MLS secure COTS-based clusters Trusted systems Malicious code detection tools Security analysis tools Security engineering for systems
Eliminate, or reduce to an acceptable level, the vulnerabilities that an adversary could exploit by obtaining information about friendly capabilities, limitations, and intentions.	Access controls/security services Reaction (isolate, correct, act) Vulnerability assessment and planning	Limited network discovery, management, security management, and expert systems capabilities Limited authentication and identification capabilities Limited ability to manage distributed information Limited classification management capability of data objects	Robust, adaptive, automated, context-based information distribution infrastructure Advanced high-speed protocol/encryption and advanced key management for tactical and strategic networks
Ensure that information is sound and unimpaired.	Information consistency Access controls/security services Service availability Network management and control Damage assessment Reaction (isolate, correct, act) Vulnerability assessment and planning Preemptive indication Intrusion detection/threat warning	Limited ability to support multilevel security, especially in coalition operations Limited availability of trusted operating systems Vulnerabilities in application of COTS items Limited authentication and identification capabilities Limited classification management capability of data objects Limited scaleable encryption	Secure firewalls and guards (B3 Level) MLS secure COTS-based clusters Trusted systems Advanced high-speed protocol/encryption and advanced key management for tactical and strategic networks

Table IV–2. Goals, Limitations, and Technologies—Information Superiority (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
C^4ISR Grid (continued)			
Operational Capability Element: High Assurance of Services (continued)			
Provide early warning of potential attacks so as to (1) alert all defensive mechanisms; (2) initiate available, reactive measures; and (3) minimize or obviate attack effectiveness.	Damage assessment Vulnerability assessment and planning Preemptive indication Intrusion detection/threat warning	Limited predictive and anticipatory network management capability Limited IW sensors, processing, and reporting for C^4ISR grid self-defense Inability of intrusion detection techniques to scale or to facilitate BDA or automated response	Automated network discovery, intrusion detection, and response capabilities Security analysis tools Secure GPS
Achieve an ability to continue to operate at some nominally acceptable level through attacks so as to avoid catastrophic failure of the system and endure into the postattack period for recovery or reconstitution or both.	Service availability Network management and control Damage assessment Reaction (isolate, correct, act) Vulnerability assessment and planning	Limited predictive and anticipatory network management capability Limited IW sensors, processing, and reporting for C^4ISR grid self-defense Inability of intrusion detection techniques to scale or to facilitate BDA or automated response Limited IW damage assessment and damage control capability Limited capability to support continued operations during network partition	Dynamic reallocation of computing resources Automated network discovery, intrusion detection, and response capabilities Security analysis tools Fault avoidance and recovery mechanisms

E. TECHNOLOGY PLAN

Achieving information superiority and seamlessly integrating IS into warfighting operations will require both advances in technology and development of new operational concepts to exploit them. Table IV–3 provides a complete list of IS DTOs. Table IV–4 maps these DTOs to operational capabilities, while Figure IV–3 traces the flow of key technologies to operational capability elements. The volume on DTOs provides further information on demonstrations and DTOs. Figures IV–4 and IV–5 provide an integrated roadmap of key demonstrations and JWSTP DTOs. Note that the IS DTOs are closely linked with a number of DTOs in the areas of Precision Force, Force Projection/Dominant Maneuver, Human Systems, Information Systems Technology, and Sensors, Electronics, and Battlespace Environment.

Table IV–3. Defense Technology Objectives—Information Superiority

DTO No.	Title
A.02	Robust Tactical/Mobile Networking
A.05	Integrated Collection Management ACTD
A.06	Rapid Terrain Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.09	Semiautomated Imagery Processing ACTD
A.10	High-Altitude Endurance Unmanned Aerial Vehicle ACTD

Table IV–3. Defense Technology Objectives— Information Superiority (continued)

DTO No.	Title
A.11	Counter-Camouflage Concealment and Deception ATD
A.12	Information Dominance (C^2 Protect and Attack for I/O ATD)
A.13	Satellite C^3I/Navigation Signals Propagation Technology
A.14	Tactical Unmanned Aerial Vehicle ACTD
A.16	Navigation Warfare ACTD
A.17	Joint Task Force ATD
A.20	Joint Warfighting Experiments
A.21	Joint Power Projection/Real-Time Support
A.22	Rapid Force Projection Initiative Command and Control TD
A.23	C^4I for Coalition Warfare ACTD
A.24	Unattended Ground Sensors ACTD
A.25	Information Operations Planning Tool ACTD
A.26	Information Assurance: Automated Intrusion Detection Environment ACTD
B.07	Joint Continuous-Strike Environment ACTD
B.25	Theater Precision Strike Operations ACTD
F.01	Synthetic Theater of War ACTD
M.02	Extending the Littoral Battlespace ACTD
HS.06.01	Joint Cognitive Systems for Battlespace Dominance
HS.21.01	Decision Support Systems for Command and Control
IS.01.01	Consistent Battlespace Understanding
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.03.01	Integrated Force and Execution Management
IS.10.01	Simulation Interconnection
IS.15.01	Assured Distributed Environment Support
IS.17.01	Defensive Information Warfare
IS.21.01	Assured Communications
IS.22.01	Network Management
IS.23.01	Digital Warfighting Communications
IS.28.02	Intelligent Information Technology
IS.34.01	Joint Force Air Component Command Battle Management
IS.47.01	Command Post of the Future
IS.48.01	Agent-Based Systems for Warfighter Support
IS.49.01	Smart Networked Radio
IS.50.01	Advanced Cooperative Collection Management
SE.02.01	Foliage Penetration Detection Algorithm Demonstration
SE.03.01	Advanced Radar Processing From Airborne Platforms

Table IV–3. Defense Technology Objectives—Information Superiority (continued)

DTO No.	Title
SE.04.02	High-Frequency Surface Wave Radar Shipboard Demonstration
SE.05.01	Automatic Radar Periscope Detection and Discrimination
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	Automatic Target Recognition for Reconnaissance and Surveillance
SE.26.01	Millimeter-Wave Power Modules
SE.27.01	Microwave SiC High-Power Amplifiers
SE.28.01	Low-Power Radio Frequency Electronics
SE.33.01	Advanced Focal Plane Array Technology
SE.35.01	Optical Processing and Memory
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.38.01	Microelectromechanical Systems

Table IV–4. Demonstration Support—Information Superiority

	Operational Capability Elements										Type of Demonstration			
	Battlespace Awareness			Effective Employment of Forces			C⁴ISR Grid							
Demonstration	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services	Service/ Agency	DTO	ACTD	ATD	TD
Robust Tactical/Mobile Networking							○	○	●	DARPA	A.02		X	
Integrated Collection Management ACTD		●								DIA	A.05	X		
Rapid Terrain Visualization ACTD	●		●							Joint	A.06	X		
Battlefield Awareness and Data Dissemination ACTD			●				○	○		DARPA	A.07	X		
Semiautomated Imagery Processing ACTD	●									DARPA	A.09	X		
High-Altitude Endurance Unmanned Aerial Vehicle ACTD	●								○	DARPA	A.10	X		
Counter-Camouflage Concealment and Deception ATD	●									DARPA	A.11		X	

● Strong Support ○ Moderate Support

Table IV–4. Demonstration Support—Information Superiority (continued)

Demonstration	Operational Capability Elements: Battlespace Awareness: Information Acquisition	Battlespace Awareness: Precision Information Direction	Battlespace Awareness: Consistent Battlespace Understanding	Effective Employment of Forces: Predictive Planning and Preemption	Effective Employment of Forces: Integrated Force Management	Effective Employment of Forces: Execution of Time-Critical Missions	C^4ISR Grid: Universal Transaction Services	C^4ISR Grid: Distributed Environment Support	C^4ISR Grid: High Assurance of Services	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD	TD
Information Dominance (C^2 Protect and Attack for I/O ATD)				●		●			●	Army	A.12		X	
Satellite C^3I/Navigation Signals Propagation Technology									●	Air Force	A.13		X	
Tactical Unmanned Aerial Vehicle ACTD	●									Joint	A.14	X		
Navigation Warfare ACTD									●	Joint	A.16	X		
Joint Task Force ATD					●			●		DARPA	A.17		X	
Joint Warfighting Experi- ments	●	●	●	○	○	○	●	●	●	DoD	A.20	X		
Joint Power Projection/ Real-Time Support					●	●				Navy	A.21			X
Rapid Force Projection Initiative Command and Control TD					●	●				Army	A.22			X
C^4I for Coalition Warfare ACTD					●		●	●		Army	A.23	X		
Unattended Ground Sensors ACTD	●	○	○							Army	A.24	X		
Information Operations Planning Tool ACTD		●		●					●	Air Force	A.25	X		
Information Assurance: Automated Intrusion Detection Environment ACTD	●								●	DISA	A.26	X		
Joint Continuous-Strike Environment ACTD			●	●	●	●				Joint	B.07	X		
Theater Precision Strike Operations ACTD			●	●	●	●				Joint	B.25	X		
Synthetic Theater of War ACTD			●		○			●		DARPA	F.01	X		
Extending the Littoral Battlespace ACTD			●		●	●		●		USMC	M.02	X		

● Strong Support ○ Moderate Support

Table IV–4. Demonstration Support—Information Superiority (continued)

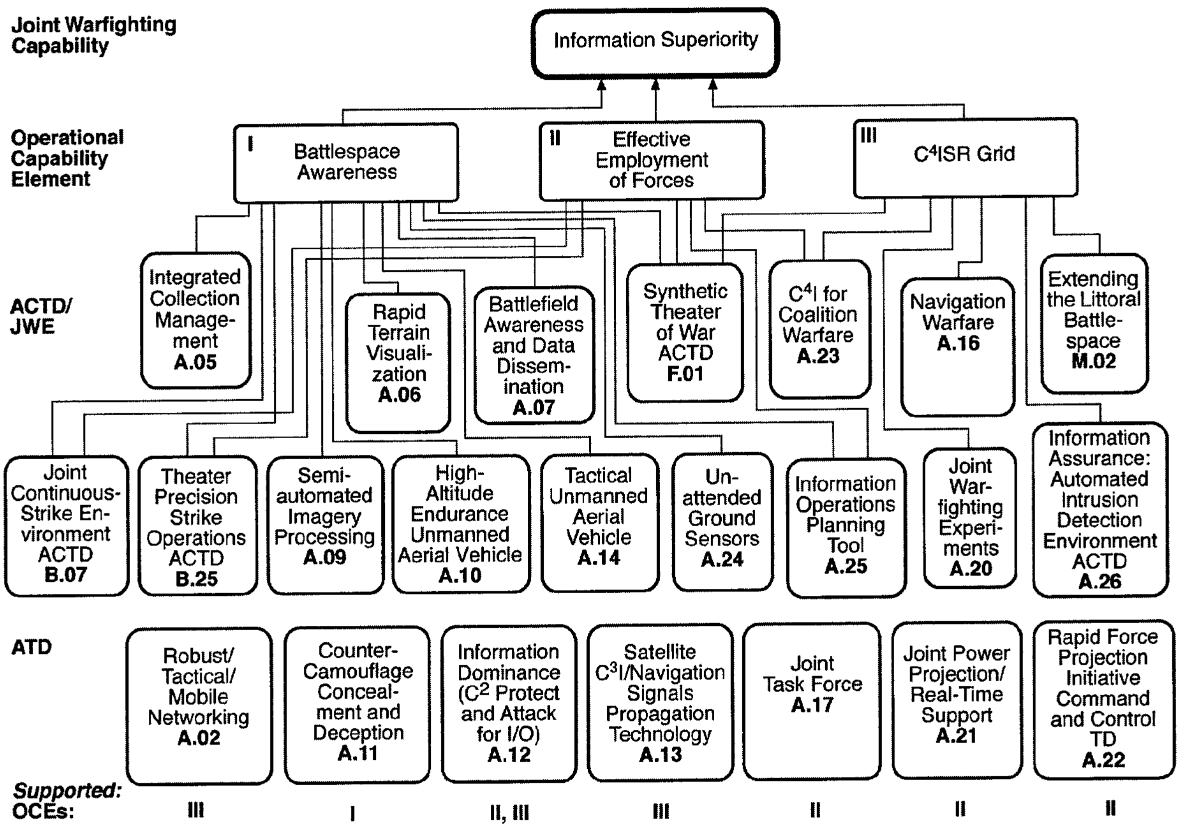
Demonstration	Operational Capability Elements									Service/ Agency	Type of Demonstration			
	Battlespace Awareness			Effective Employment of Forces			C^4ISR Grid							
	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services		DTO	ACTD	ATD	TD
Joint Cognitive Systems for Battlespace Dominance		○	●	○						Army, Air Force	HS.06.01			
Decision Support Systems for Command and Control	●	●	●		●	●	○	○		Navy	HS.21.01			
Consistent Battlespace Understanding			●							Army	IS.01.01			
Forecasting, Planning, and Resource Allocation				●						Army	IS.02.01			
Integrated Force and Execution Management				●	●	●				Army	IS.03.01			
Simulation Interconnection			●							Joint	IS.10.01			
Assured Distributed Environment Support	○							●	●	DARPA	IS.15.01			
Defense Information Warfare	●		●						●	DARPA	IS.17.01			
Assured Communications							○		●	Air Force	IS.21.01			
Network Management							●	●	●	DARPA	IS.22.01			
Digital Warfighting Communications			○		○	○			●	Army	IS.23.01			
Intelligent Information Technology	●						●	●	●	DARPA	IS.28.02			
Joint Force Air Component Command Battle Management			●	○	●	●				DARPA	IS.34.01			
Command Post of the Future	●			○	●					DARPA	IS.47.01			
Agent-Based Systems for Warfighter Support				●		●				DARPA	IS.48.01			
Smart Networked Radio	●							●	○	Army	IS.49.01			
Advanced Cooperative Collection Management	●									DARPA	IS.50.01		X	
Foliage Penetration Detection Algorithm	●		●	●		●				Air Force	SE.02.01			

● Strong Support ○ Moderate Support

Table IV–4. Demonstration Support—Information Superiority (continued)

	Operational Capability Elements										Type of Demonstration			
	Battlespace Awareness			Effective Employment of Forces			C⁴ISR Grid							
Demonstration	Information Acquisition	Precision Information Direction	Consistent Battlespace Understanding	Predictive Planning and Preemption	Integrated Force Management	Execution of Time-Critical Missions	Universal Transaction Services	Distributed Environment Support	High Assurance of Services	Service/ Agency	DTO	ACTD	ATD	TD
Advanced Radar Processing From Moving Platforms	●		●	●		●				Air Force	SE.03.01			
High-Frequency Surface Wave Radar Shipboard Demonstration	●		●	●						Navy	SE.04.02			
Automatic Radar Periscope Detection and Discrimination	●		●	●						Navy	SE.05.01			
Affordable ATR via Rapid Design, Evaluation, and Simulation	●									Army, Air Force	SE.19.03			
Automatic Target Recognition for Reconnaissance and Surveillance	●									Joint	SE.20.01			
Millimeter-Wave Power Modules		○				○			●	Navy	SE.26.01			
Microwave SiC High-Power Amplifiers				●						Navy	SE.27.01			
Low-Power Radio Frequency Electronics	○					○			●	Navy	SE.28.01			
Advanced Focal Plane Array Technology	●		○							DARPA	SE.33.01			
Optical Processing and Memory	○	○	○						●	Air Force	SE.35.01			
High-Density Radiation-Resistant Microelectronics						●		○	●	DSWA	SE.37.01			
Microelectromechanical Systems	○								●	DARPA	SE.38.01			

● Strong Support ○ Moderate Support



Supporting DTAP DTOs

HS.06.01	Joint Cognitive Systems for Battlespace Dominance
HS.21.01	Decision Support Systems for Command and Control
HS.23.02	Immersive, Adaptive Interfaces for Unmanned Vehicles
IS.01.01	Consistent Battlespace Understanding
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.03.01	Integrated Force and Execution Management
IS.10.01	Simulation Interconnection
IS.15.01	Assured Distributed Environment Support
IS.17.01	Defensive Information Warfare
IS.21.01	Assured Communications
IS.22.01	Network Management
IS.23.01	Digital Warfighting Communications
IS.28.02	Intelligent Information Technology
IS.34.01	Joint Force Air Component Command Battle Management
IS.47.01	Command Post of the Future
IS.48.01	Agent-Based Systems for Warfighter Support
IS.49.01	Smart Networked Radio
IS.50.01	Advanced Cooperative Collection Management
SE.02.01	Foliage Penetration Detection Algorithm
SE.03.01	Advanced Radar Processing From Airborne Platforms
SE.04.02	High-Frequency Surface Wave Radar Shipboard Demonstrations
SE.05.01	Automatic Radar Periscope Detection and Discrimination
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	Automatic Target Recognition for Reconnaissance and Surveillance
SE.26.01	Millimeter-Wave Power Modules
SE.27.01	Microwave SiC High-Power Amplifiers
SE.28.01	Low-Power Radio Frequency Electronics
SE.33.01	Advanced Focal Plane Array Technology
SE.35.01	Optical Processing and Memory
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.38.01	Microelectromechanical Systems

Figure IV–3. Technology to Capability—Information Superiority

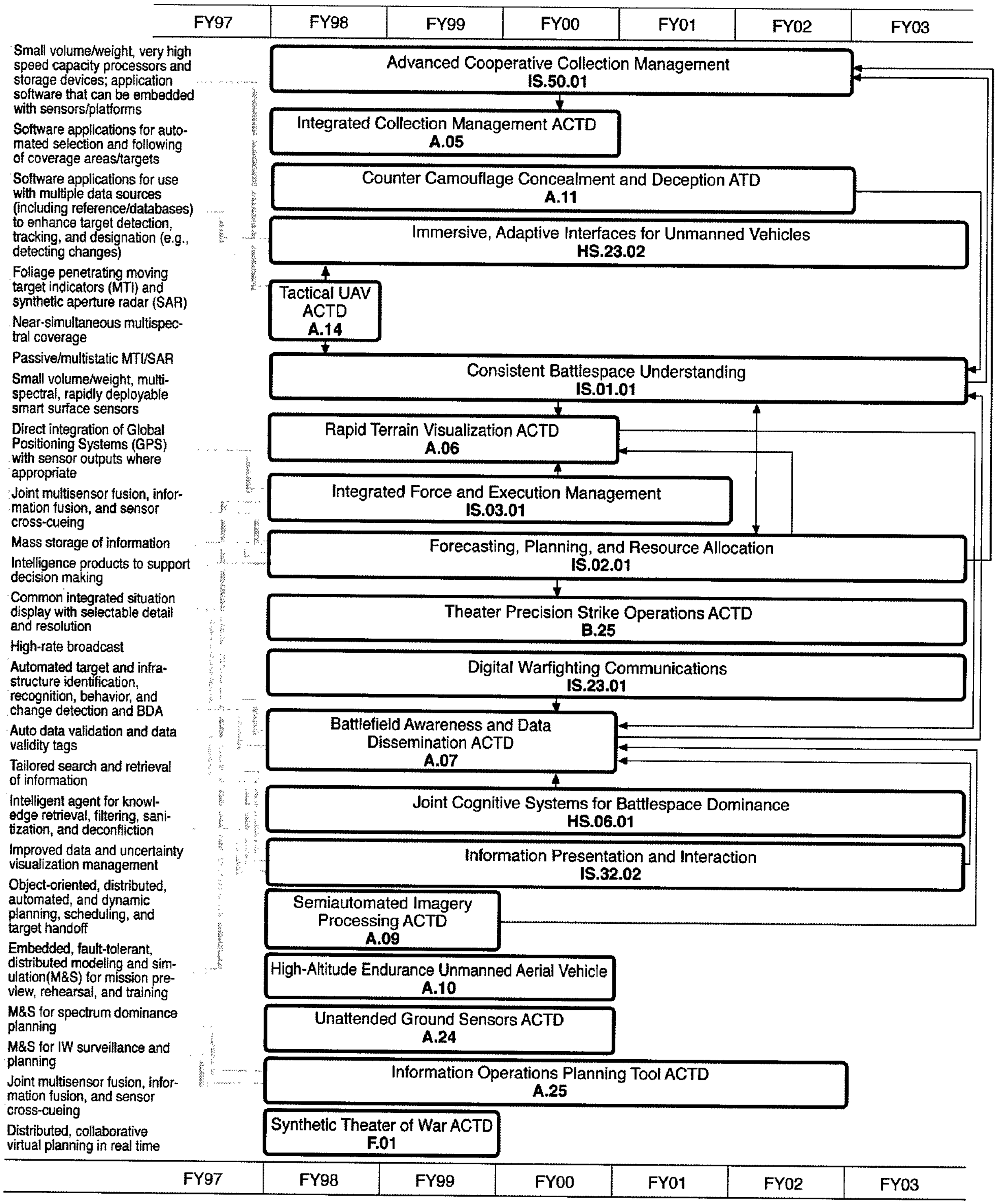


Figure IV–4. Roadmap—Information Superiority, Battlespace Awareness Capability Area

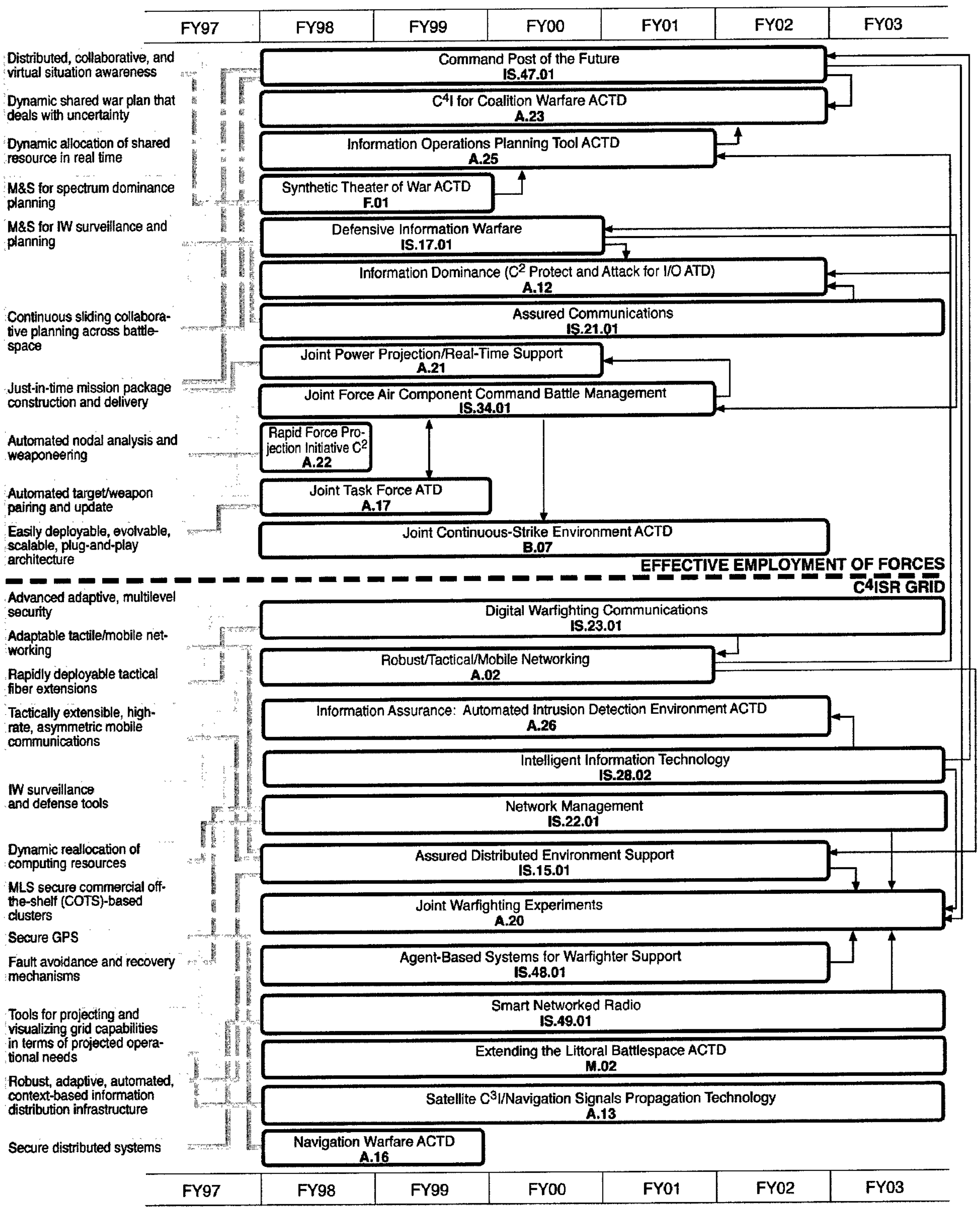


Figure IV-5. Roadmap—Information Superiority, Effectiveness Employment of Forces and C⁴ISR Grid Capability Areas

The current JWSTP program includes a number of demonstrations recommended by the ABIS report (Reference 13), although most are demonstrations of partial ABIS capabilities. These provide the basis for immediate improvements in battlespace awareness and the integration of improved knowledge into mission planning and execution. These demonstrations also support new concepts of C^4ISR operation and improvements in the warfighter's ability to use ISR assets. These will demonstrate the value of information superiority to the operational forces and provide a strong foundation on which to build an effective long-term program to achieve the JCS's future warfighting vision. In addition, new C^4ISR capabilities and concepts will immediately begin to affect capabilities and concepts of operation in all other warfighting areas.

The IS DTOs listed in Table IV–3 also cover a wide range of initial IW needs. The Navigation Warfare ACTD (A.16) is aimed toward improving the survivability of GPS information. Information Dominance (A.12) will provide an electronic attack capability against advanced communications in use today as well as those that are being further developed as recognizable potential threats in future conflicts.

The following is a summary of the Information Superiority DTOs:

- *A.02, Robust Tactical/Mobile Networking*, will develop the technology to provide a high-bandwidth, robust, multimedia, theater-level communications networking infrastructure that can be rapidly deployed to support military operations. This will include the demonstration of new mobile routing cellular/personal communications services, over-the-horizon connectivity for isolated and rapidly maneuvering forces, and the ability to exchange multimedia data through an Internet-like network. As a result, interactive sessions or imagery transfers on the battlefield will take place in seconds rather than in minutes or hours, even under the most stringent user demands.
- *A.05, Integrated Collection Management ACTD*, will provide an initial capability for dynamic retasking and will demonstrate integrated collection management (ICM) of signals intelligence (SIGINT) and imagery intelligence (IMINT) from national and theater sensors. This will include providing tasking-level data and status feedback to the JTF, dynamic integrated tasking of sensors from all-source strategies and cross-cueing of collection assets, and tasking inside friendly and enemy operating cycles in less than 24 hours, with an ultimate goal of 2–4 hours.
- *A.06, Rapid Terrain Visualization ACTD*, will develop and demonstrate the rapid collection and generation of high-resolution digital terrain elevation data using imagery from aircraft and space platforms and the use of this data to generate terrain feature data and map backgrounds. This will enable the JTF commander to integrate terrain databases with current situation data, including intelligence, C^2, logistics, and weather.
- *A.07, Battlefield Awareness and Data Dissemination ACTD*, will provide the capabilities for forward warfighters to access and utilize very large information products that were previously inaccessible, and to seamlessly integrate these products with emerging 3D visualization applications. It will also provide information profiling services that will allow users to specify and control the flow of information into their forward sites, policy management services that allow commanders to manage information flows, and wideband delivery services that allow these services to operate across high-bandwidth broadcast links.

- *A.09, Semiautomated Imagery Processing ACTD*, will allow the image analyst to rapidly analyze imagery, generate reports, and produce imagery products in support of the joint warfighter's requirements. Key technologies include real-time synthetic aperture radar (SAR) image-to-image registration, high-definition imaging, object-level change detection, terrain analysis, cluster analysis, template-based automatic target recognition (ATR), and advanced tools for human–computer interface.
- *A.10, High-Altitude Endurance Unmanned Aerial Vehicle ACTD*, will develop and demonstrate a joint, adverse-weather, long-endurance, wide-area, day/night reconnaissance and surveillance capability in both a low-observable and conventional configuration. This will provide the joint warfighter with continuous, broad-area battlefield surveillance that has real-time connectivity to existing service exploitation centers.
- *A.11, Counter-Camouflage Concealment and Deception ATD*, will provide the warfighter the ability to detect and classify targets obscured by foliage and tactical deception techniques. A concept of operations (CONOPS) will be developed that will use this class of sensors on the Predator and Global Hawk unmanned air vehicles, and integrate the image exploitation capability from the battlefield into the semiautomated IMINT processing Common Integrated Ground/Surface System (CIGSS) architecture being developed under DTO A.09.
- *A.12, Information Dominance (C^2 Protect and Attack for I/O ATD)*, will develop, integrate, and validate hardware, software tools, tactics, techniques, and procedures that will secure the systems and networks of the Army's Tactical Internet and the First Digitized Division. This will provide new operational capabilities in the areas of advanced network access control, secure tactical network management, auditing, intrusion detection, and response mechanisms. It will also develop attack tools, techniques, and applications that will be integrated into existing or emerging intelligence and electronic warfare systems.
- *A.13, Satellite C^3I/Navigation Signals Propagation Technology*, will provide reliable real-time specifications and forecasts of ionospheric conditions and disturbances, and their effects on communications, surveillance, and navigation systems, including the Global Positioning System (GPS). This will allow radio frequencies, modulation schemes, data rates, and other system parameters to be set to match what the prevailing ionosphere will allow. Timely, reliable, advance warnings of disruptive ionospheric (scintillation) disturbances will allow operators time to adjust system parameters to mitigate those effects and, if necessary, switch to backup systems to ensure uninterrupted C^3I operations.
- *A.14, Tactical Unmanned Aerial Vehicle ACTD*, will provide timely, accurate, and complete targeting and other battlefield information in near-real time. This DTO will be complete in FY98, resulting in a deployable configuration with modular mission payloads suitable for shipboard operations.
- *A.16, Navigation Warfare ACTD*, will provide a limited number of GPS protection (enhanced receiver) and prevention (jammer) assets to the operational warfighter. Through assessment of the military utility of the assets produced by this ACTD in operational training exercises, advanced technology equipment will be developed and refined at a much faster rate than through normal acquisition.

- *A.17, Joint Task Force ATD*, will provide the warfighter with a scaleable, joint distributed, collaborative, crisis planning, replanning, and execution system. This will result in enhanced collaboration, visibility, and common perception of the battlespace. Technologies to be demonstrated include Common Object Request Broker Architecture (CORBA), object webs, adaptive objects, C^2 schema, bandwidth-adaptive networking, distributed collaboration, mobile code, and modeling and simulation.

- *A.20, Joint Warfighting Experiments (JWEs)*, will provide the capability to more rapidly develop, evaluate, and integrate new sensor technologies, information systems, and engagement planning and execution systems. The ultimate goal is to achieve an open-architecture end-to-end system that will allow joint and coalition forces to rapidly configure and interconnect the right information resources in the right place at the right time.

- *A.21, Joint Power Projection/Real-Time Support (JPP/RTS)*, will provide the ability to address fleet requirements for C^4ISR technology development and demonstration leading to warfighter evaluation and early implementation of the following capabilities: (1) sensor-to-shooter use of real-time data for mission execution and targeting, (2) next-generation shipboard C^4ISR system definition, and (3) network-centric battle management for distributed collaborative planning and execution.

- *A.22, Rapid Force Projection Initiative Command and Control (RFPI C^2) TD*, will demonstrate an integrated and enhanced sensor-to-shooter linkage for early-entry light forces. The RFPI C^2 TD program, which will be completed at the end of FY98, will deliver a fully tactical Light Digital Tactical Operations Center (LDTOC) simulator to the 101st Airborne Division at Fort Campbell. In addition, three vehicles of a brigade tactical command post (TAC) will be digitally equipped and connected to the LDTOC.

- *A.23, C^4I for Coalition Warfare ACTD*, will allow the U.S. Army to achieve message- and data-replication-based interoperability between its C^2 systems and those of its allies at corps through battalion level. Key technologies to be integrated include an internationally standardized data model, international preformatted messages (based on NATO standards), message parsing software, and an internationally developed data replication mechanism.

- *A.24, Unattended Ground Sensors (UGS) ACTD*, will address solutions to problems involved in the use of unattended ground sensors against time-critical targets and in adverse weather conditions. This DTO involves both acoustic and seismic detection and identification sensors as well as weather sensors. The end-to-end supporting technologies include planning tools, air delivery techniques, communications subsystems, and data exploitation tools.

- *A.25, Information Operations Planning Tool (IOPT) ACTD*, will support the planning, development, synchronization, deconfliction, and management of an information operations campaign integrated between a joint HQ staff and the CINC components. The ACTD will also show how modeling and analysis tools with connectivity to current intelligence databases and a reachback capability to a garrison force can support the development of target recommendations and optimized courses of action aligned with CINC information operations taskings against an integrated air defense system.

- *A.26, Information Assurance: Automated Intrusion Detection Environment (IA:AIDE) ACTD*, will develop a capability to address the question, Are our information systems under attack? IA:AIDE is an effort to develop an initial "cyber radar" to detect coordinated attacks on the military information infrastructure. The program will provide an integrated suite of capabilities to detect attacks; provide data reduction, correlation, and visualization; and perform network operations.

Near-term demonstrations will provide a basis for further improvements in tactical integration, real-time management of C^4ISR, and dynamic retasking of forces; and for better integration of concurrent planning and execution at the system level in the 2000–2005 timeframe. The prototype C^4ISR grid capabilities demonstrated in the near term will begin to evolve into the type of massive, heterogeneous, distributed, and responsive information services environment envisioned in the long-term ABIS objectives.

Further advances and demonstrations are required for the 2000–2010 timeframe to ensure the availability of information superiority, and the secure and effective services that the warfighters will need in future conflicts. The Information Systems and Technology DTOs cover a number of longer term objectives, discussed in the *Defense Technology Area Plan.* These DTOs will demonstrate IS capabilities in support of new operational concepts to achieve overwhelming effect across the full spectrum of dominant maneuver, precision engagement, full-dimension protection, and focused logistics capabilities envisioned by the ABIS study. Transitions from demonstrations associated with DTOs into fieldable systems integrated with a common architecture are critical to providing the joint warfighter with these technical capabilities.

F. SUMMARY

The programs described above will demonstrate and evaluate a wide range of potential IS improvements over the next 3 to 5 years. Realizing the incremental improvements that lead to the JCS chairman's revolutionary vision of overwhelming dominance in the battlespace will require a continuing long-term commitment not only within the S&T program but also to integrating these capabilities into systems. A similar commitment is required to continually reassess and update operational concepts, doctrine, and tactics in conjunction with changes in technology and threat. These efforts, coupled with the projected continued doubling every 2 years of the performance of the underlying information system hardware, should result in significant incremental improvements in the warfighters' visibility and command of the battlespace, as well as in the availability of accurate, detailed sensor-to-shooter information (see Figure IV–6).

Between now and the year 2000, improvements in force employment capabilities will largely be based on better target recognition and timely attack, improved C^2 early in the campaign, the beginnings of a defensive IW capability, and an improved information environment for collaborative work. Battlespace awareness will be improved by providing a consistent situational picture and an ability for the integrated tasking of signals intelligence (SIGINT) and imagery intelligence (IMINT) capabilities. Improved awareness capabilities will support tactical needs and provide real-time sensor information directly to shooters. C^4ISR grid capabilities will be improved to support more rapid configuration of tactical networks (including nodes for mobile users) with enhanced abilities to integrate and distribute information securely in a broadly heterogeneous environment.

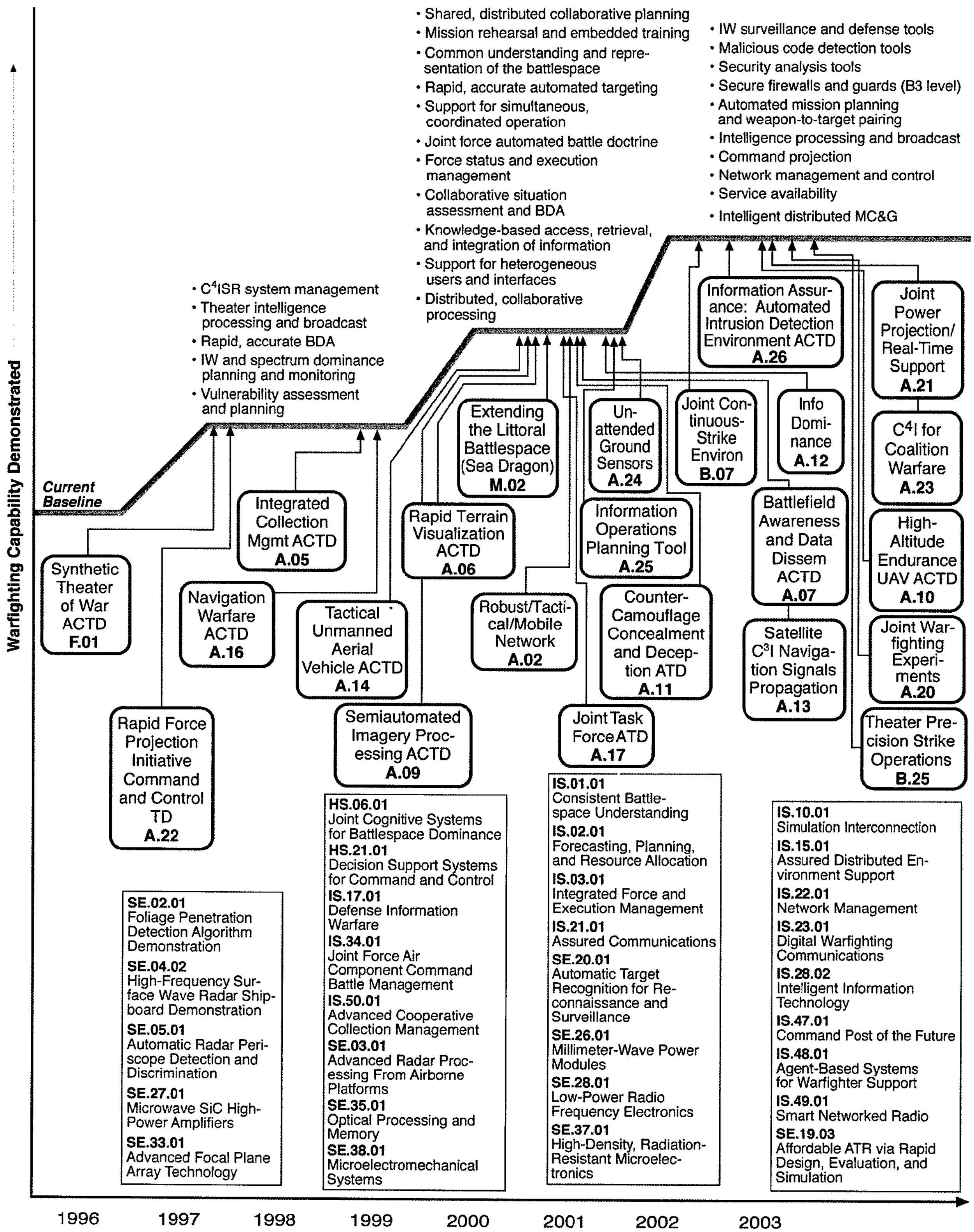


Figure IV–6. Progress—Information Superiority

In the longer term (2000–2010), the continued evolution of operational concepts and the availability of new technologies will provide a basis for the full development of ABIS concepts. Further improvements in force employment capabilities will be possible through wider dissemination of each commander's intent. Improved automated tools for local decision making, coupled with better status information and an ability to forecast likely future options and contingencies, would enhance the ability of commanders at all levels to reason from ambiguous information and to tailor force and mission packages to meet the needs of an ongoing conflict. Battlespace awareness capabilities will be enhanced by continuously projecting friendly and enemy moves and their likely outcomes, by adaptively supporting cognitive functions of diverse users, and by providing tailored information for mission execution when and where it is needed. C^4ISR grid capabilities will be made more robust by advances in adaptive network management and information warfare, and by providing end users with an ability to tailor and adapt their information environment and access to information.

Information warfare is a relatively new joint warfighting area that is integrated into all three IS broad operational capability areas. Near-term capabilities will internetwork warfighters at the tactical level, improve the security and reliability of distributed databases, and provide improved protection techniques. Midterm capabilities will take advantage of high-bandwidth, encrypted links to internetwork warfighters at varying levels of security, and provide a suite of IW planning tools and effectiveness models. The successful advancement of these technologies will ensure the availability, confidentiality, and integrity of information by providing the warfighter with a robust, adaptive, automated, context-based information infrastructure and suites of tools to protect friendly information systems, while adaptively managing our own information management services.

It is important to recognize that the information warfare threat is real. IW capabilities, at various levels, are widely available throughout the world. DoD systems, particularly those that are unclassified, are currently vulnerable. While a concerted, coordinated attack against DoD interests would require considerable resources, significant focused damage to DoD information systems is already possible. The S&T community takes this threat seriously and will continue to focus funding on key technologies that support the joint warfighter IW requirements.

These recommended DTOs take fully into account commercially available technology and often utilize such technology. However, even with the continued capability improvements of commercial information systems, it will be a great challenge to meet the demand for greater bandwidth, processing throughput, and faster response time. In addition, unique technology will be required for capabilities needed only by the military. Also, in some areas, military capability is needed earlier than the commercial market has sufficient demand to justify.

While all the DTOs listed here are important critical components of the IS capability envisioned by *Joint Vision 2010* and articulated in ABIS, they are insufficient. Out-year demonstrations will be needed to illustrate and validate additional advances. The emphasis in the out-year program will need to be on development and demonstration of essential intelligent, adaptable capabilities to ensure availability and security of services at all echelons and to support dominance in all types of conflict.

Information superiority, with integrated information warfare capabilities, represents a new tenet in military doctrine. The appropriate investment in the supporting technologies will enable DoD to achieve military superiority through information superiority.

CHAPTER V

PRECISION FORCE

CHAPTER V
PRECISION FORCE

A. DEFINITION

Precision Force is defined as the capability to destroy selected high-value and time-critical targets, or to inflict damage with precision, while limiting collateral damage. Precision Force consists of three elements: (1) target acquisition, (2) command and control to provide a capability to bring fire to bear on targets, and (3) precision munitions to produce desired target effects. The Precision Force Joint Warfighting Capability Objective (JWCO) does not stand alone; rather, it supports and complements the related JWCOs of Joint Theater Missile Defense (Chapter VII), Chemical/ Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction (Chapter XII), and Information Superiority (Chapter IV), among others, as well as supporting technologies such as Weapons, Air Platforms, Sensors and Electronics, and Information Systems Technology, which are discussed in the *Defense Technology Area Plan* (DTAP).

Attainment of the Precision Force JWCO is critical to achieving the Precision Engagement operational concept, but it does not satisfy the entire concept because critical ingredients are missing. The Precision Engagement operational concept introduced in *Joint Vision 2010* is not the same as Precision Force. Precision Engagement is a system of systems that enables our forces to locate the objective (or target), provide responsive command and control, generate the desired effect, assess our level of success, and retain the flexibility to reengage with precision when required. Precision Engagement provides selective direct connectivity between intelligence, surveillance, and reconnaissance sensors and "shooters" so our forces can achieve nearly instantaneous destruction of high-priority, time-sensitive targets or objectives. This capability enhances our ability to achieve desired target effects and assess damage in real time. In summary, Precision Engagement consists of five elements: (1) target acquisition, (2) command and control to provide the capability to bring fire to bear on targets, (3) ability to produce desired target effects, (4) battle damage assessment, and (5) the ability to reengage targets if necessary. Precision Engagement thus involves acquiring, striking, and destroying all types of threat land, sea, and air targets, to include weapon platforms, hardened underground storage and production facilities for weapons of mass destruction, theater missiles, logistics facilities, and command and control facilities.

In addition to Precision Force, achievement of Precision Engagement will also require that the JWCOs of Joint Theater Missile Defense, Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction, and Information Superiority, as a minimum, are achieved. Figure V–1 illustrates that the Precision Engagement operational concept consists of Precision Force (majority), plus significant portions of other JWCOs and supporting technologies. Information Superiority, as an example, will permit our joint warfighters at all echelons to access time-critical information about threat targets and obtain battle damage assessment information from common databases and effectively use this information to achieve Precision Engagement. Counter Weapons of Mass Destruction will provide the capability to engage WMD storage and production facilities with precision, so as to limit collateral damage. Joint Theater Missile Defense will provide the capability to precisely engage threat theater and cruise missiles. Thus, the realization of a number of the JWCOs and some critical supporting technologies is required to fully achieve the Precision

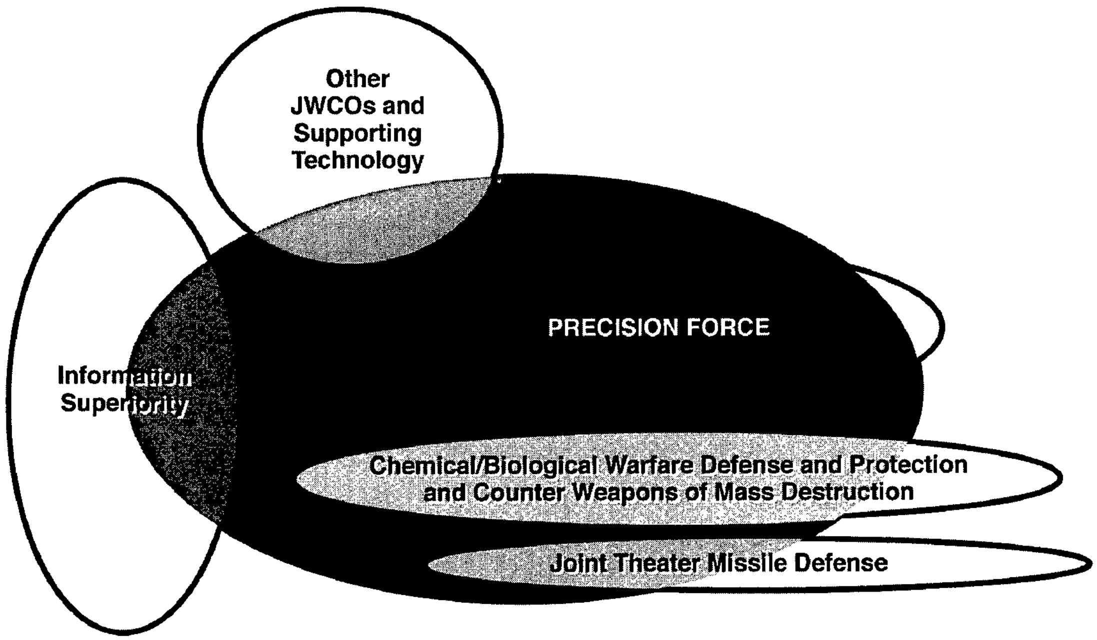


Figure V–1. Concept—Precision Engagement

Engagement operational concept. Air/sea superiority and certain components of force protection (air, sea, ground force defense) are also an integral part of Precision Force.

Precision Force supports mission requirements to rapidly neutralize hostile assets for communication, command and control, and mobile or fixed weapons of mass destruction (WMD) by attacking and destroying enemy forces and their supporting infrastructure. The realization of Precision Force requires advances in sensors, C^2 interoperability, battle management, and lethality, including effective human interface and equipment. It also requires precision-guided munition enhancements for increased weapon range, accuracy, and effectiveness. Additionally, sensor-to-shooter enhancements in C^4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) are necessary for responsive and timely force application.

Figure V–2 shows a typical concept of Precision Force. Additional components, not shown in this figure, include land- and sea-launched fighter and bomber aircraft, Tomahawk Land Attack Missiles (TLAMs), and naval gunfire.

B. OPERATIONAL CAPABILITY ELEMENTS

Mission space is no longer linear or sequential. Given a digitized battlespace environment with C^4ISR, the partitioning between land, sea, and air mission space disappears, and the effective inclusion of human operators and decision makers becomes more difficult. The precision force concept is achievable only with heavy reliance on many technologies being developed to support other JWCOs. By drawing on these capabilities, the joint area commander will be able to attack and neutralize enemy forces and capabilities throughout the breadth and depth of the mission space to break the coherence and continuity of the enemy's operations.

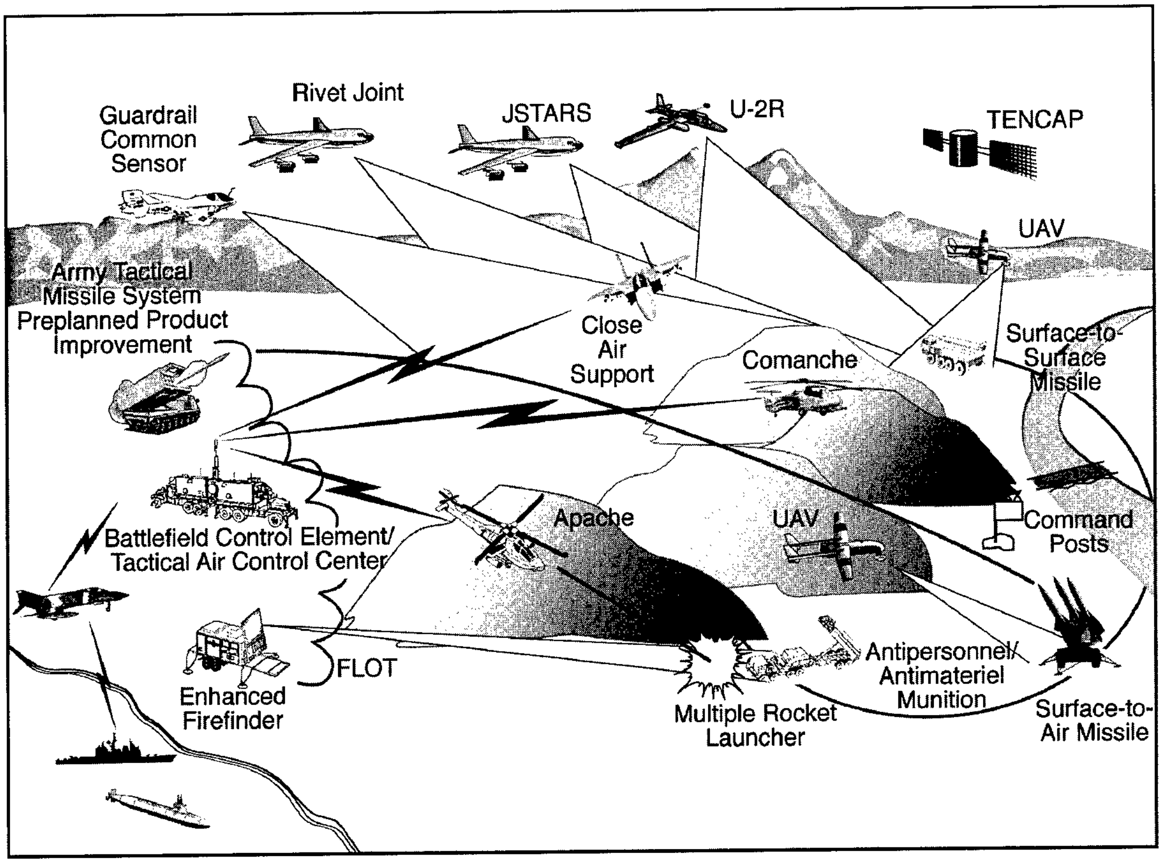


Figure V–2. Concept—Precision Force

The key operational capability elements associated with Precision Force are:

- Mission planning
- C⁴ISR
- Weapon employment
- Combat assessment.

Mission Planning. The mission planning operational capability element is strongly dependent on, but not limited to, battlespace management, target prioritization, long-range sensors, and timely intelligence dissemination to the user. Once the target has been identified (by national assets or by air or ground targeting systems) and a strike requested, the mission planning process begins. As part of this process, target surveillance is continued and situational awareness is maintained. Target priorities are set and primary strike assets selected. Mission planning continues into weapon employment, as a seamless function, as described below.

C⁴ISR. C⁴ISR technologies are the enabling technologies for the Precision Force concept. Without the ability to communicate in near-real time between the battlefield and fire support elements (air, land, sea, or ground based), the destruction of time-critical targets becomes problematic. To fulfill future battlespace demands, targets must be identified and destroyed quickly—a function highly dependent on effective correlation and fusion of data from different sensors. The technology

exhibited as part of the Precision Rapid Counter Multiple Rocket Launcher (PRCMRL) ACTD—such as Matrix, Terrain Evaluation Module (TEM), and Top Scene—will greatly assist in the intelligence preparation of the battlefield and will allow both key decision makers and planners to rapidly share a common perception of the battlefield. In addition, the capabilities demonstrated during the Precision SIGINT Targeting Systems (PSTS) ACTD is an effort to develop and demonstrate a near-real-time, precision targeting sensor-to-shooter capability using existing national and tactical assets.

Weapon Employment. Once the strike asset is selected (e.g., air- or sea-launched cruise missile) and target acquisition is made either by the strike munition or the system selected to interface with the strike munition, the weapon is launched. With a real-time update to commanders of the battlespace situation, including continuous target surveillance, the strike munition can be retargeted after launch, should the initial target be destroyed by another asset, or should another target become a more serious, time-critical threat.

Combat Assessment. Combat assessment (which is vital for gauging attack effectiveness), planning follow-up strikes, and assessing the enemy's ability to continue are strongly dependent on, but not limited to, 24-hour, all-weather sensors, responsive targeting and planning products, and counter-camouflage, concealment, and deception (CC&D) penetration.

C. FUNCTIONAL CAPABILITIES

Precision force operational capability elements are made possible by a number of functional capabilities. Table V–1 identifies these functional capabilities and shows the linkages with operational capabilities.

Recent RAND studies have indicated that the combination of Army, Navy, and Air Force standoff weapons and sophisticated reconnaissance and targeting systems—coupled with efficient counterbattery systems—can be shown to be more effective than current forces that rely on direct-fire, line-of-sight (LOS) technologies (References 14 and 15). A Division Ready Brigade operating with the support of Air Force or Navy precision weapons would have significantly enhanced lethality against a heavily armored force employing Russian equipment and Russian-style tactics by employing hunter/standoff killer (HSOK) systems. HSOK weapons introduce the benefits of an indirect, precision-fire battlefield. The HSOK systems attain viability because of emerging technologies that enable the battle to commence earlier and at greater range, extend the battle to non-LOS battlespace, and meter surviving enemy heavy forces at a reduced rate such that direct-fire systems become increasingly effective.

Table V–1. Functional Capabilities Needed—Precision Force

Functional Capabilities	Operational Capability Elements						
	Mission Planning		Weapon Employment				
	Planning	Surveillance and Reconnaissance	Target Acquisition	Weapon System Employment	Survivability	Combat Assessment	C^4ISR
1. Scheme of Operations	●	●	●	●	●	●	●
2. Battlespace Management	●	●	○	○	○	○	●
3. Intelligence Preparation of the Battlefield	●	●	●	○	○	●	●
4. Target Priorities	●	●	●	●	○	○	○
5. Weapons (resource) Allocations	●	○	○	●	●	○	○
6. Target Database	●	●	○	●	●	○	○
7. Round-the-Clock, Day/Night, All-Weather Coverage (sensors)	●	●	●	●	○	●	○
8. Counter CC&D Penetration	○	●	●	●	○	●	○
9. Responsive Targeting/Planning Products	●	●	●	●	○	●	●
10. Long-Range Sensors (deep look)	●	●	●	○	○	●	●
11. Survivable	●	●					
12. Area Coverage	●	●	●	○	○	●	○
13. Correlation/Fusion	●	●	●			●	●
14. Timely Intelligence Dissemination to User (planner and shooter, RTIC)	●	●	●	○	●	●	●
15. Timely Sensor Retasking		○	●			●	●
16. Timely and Accurate Location or Track Data		○	●				
17. Combat ID			●			●	●
18. Automatic Target Recognition		●	●	●		●	●
19. All-Weather, Day/Night Capable	○	●	●	●		○	
20. Responsive				●		○	
21. Long Range	●			●	●		
22. Flexible Weapon Platform (precision)	●			●			
23. Lethal (precision)	●	○		●			
24. Discriminate/Combat Identification			○	●	○		
25. Base Defense/Force Protection	●				●		
26. Air/Sea Superiority			○	○	●		
27. Suppression of Enemy Air Defense (SEAD)	○			○	●	○	
28. Timely Product	○	○				●	●
29. Accuracy		●	●	●		●	
30. Updates to Targeting Database	○					●	
31. Secure, Interoperable C^4 Structure (communications, databases, protocols, etc.)	●	●	○	○	○	○	●

● Strong Support ○ Moderate Support

Table V–1. Functional Capabilities Needed—Precision Force (continued)

Functional Capabilities	Operational Capability Elements: Mission Planning: Planning	Mission Planning: Surveillance and Reconnaissance	Weapon Employment: Target Acquisition	Weapon Employment: Weapon System Employment	Weapon Employment: Survivability	Combat Assessment	C4ISR
32. Dynamic Database	●	●	○	○		●	
33. Proactive Architecture ("pull" right information at the right time system)	●		●	●	●	●	
34. Geopositioning	●	●	●	●	●	●	●
35. Joint Battlefield Architecture	●	●	○			○	●

● Strong Support ○ Moderate Support

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

Operational capability elements and associated limitations are presented in Table V–2. Major deficiencies confronting the area of mission planning are the timely combat decision and resource allocation processes in relation to target cycle time, the detection of highly mobile targets in crowded mission space, slow processes for fusing various service automated mission planning systems for target information, and time-consuming and incomplete battle damage information and assessments.

Table V–2. Goals, Limitations, and Technologies—Precision Force

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Mission Planning			
Provide a real-time, fused, battlespace picture with integrated decision aid tools. This will ensure coordinated and dynamic planning and execution of a broad spectrum of missions from time-phased attack of targets to reconnaissance of battle areas and prosecution of time-critical targets by integrated hunter-killer controller assets.	*Planning* Scheme of operations Battlespace management Intelligence preparation of the battlefield Target priorities Weapons (resource allocation) Target database *Surveillance and Reconnaissance* Round-the-clock, day/night/all-weather coverage (sensors) Counter-CC&D penetration Responsive targeting/planning product/timely dissemination Long-range sensors Survivable Area coverage Correlation/fusion	Costly Required training Real-time response Integration with aircraft is limited; may have to type in data after planning Cannot do mission planning/replanning in aircraft Services use different systems	Integrated target track Multisensor ATR Real-time cognizant aiding display Strike weapon adaptable video and communications technology Battlespace C&C Real-time template/weapons retargeting Focal planes Sensor fusion Planning tools Improved propulsion (reduced time of flight) Improved warheads (fewer weapons/launchers)

Table V–2. Goals, Limitations, and Technologies—Precision Force (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Weapons Employment			
Provide processing and linkages that enable rapid target search and acquisition, battle coordination and target selection, and handoff and engagement for prosecution of time-critical targets.	*Target Acquisition* Timely intelligence dissemination to user (planner and shooter) Timely sensor retasking Timely and accurate location or track data Combat ID—cooperative and noncooperative systems ATR *Weapon System Employment* All-weather, day/night capable Responsive Sufficient range Flexible weapon platform (precision)—retargetable Lethal (precision) Discriminate/combat ID *Survivability* Base defense/force protection Air superiority Suppression of enemy air defense	Mobile target engagement GPS jamming Affordability Battle damage assessment (BDA) Following capabilities required: • All-weather, 3-m CEP weapon • Low collateral hard target weapon • Hypersonic weapons • IFF • High off-boresight, high angle of attack • Nonlethal weapons	Multisensor ATR Real-time cognizant aiding display Remote sentry Real-time template/weapons retargeting Miniaturizing GPS and laser radar Advanced unitary penetrator Antijam GPS technology flight test SAR guidance Hard-target smart fuze Differential GPS and terminal guidance Miniature navigation system High-g-load IR target seeker Sensor fusion and NLOS weapons Shallow-water torpedo G&C Smart skins arrays High stress/load structure Multimode warhead MEMS Helmet-mounted displays Improved platform/weapon control systems and structures Advanced propulsion (faster, longer range)
Operational Capability Element: Combat Assessment			
Provide ability to determine near-real-time physical effect of force application to targets and quickly assess impact on in-theater operations.	Timely sensor retasking All-weather, day/night capable Real-time response Accuracy Interoperable updates to targeting database	Real-time response Services use different systems BDA Tasking Limited tactical assets F–14 (TARPS) + UAV Counter CC&D	Strike weapon adaptable video and communications technology Sensor fusion and NLOS weapons Joint precision strike
Operational Capability Element: C^4ISR			
Provide joint core mission planner with fully automated "virtual battlefield view" (100 percent consistent across echelons, with aggregation), which results in direct sensor/shooter tasking in <1 minute with predictive delivery of electronic mission support.	Survivable Secure, interoperable C^4 structure (communications, databases, protocols, etc.) Dynamic database Proactive architecture (pull right information at the right time) Geopositioning Joint battlefield architecture	Real-time response Services use different systems Too much or too little data No/limited fusion of data (i.e., same track from multiple sources or sensors) UHF limited to line of sight	Strike weapon adaptable video and communications technology Real-time template/weapons retargeting Digital battlefield communications Battlespace C&C Precision SIGINT target Low probability of intercept (LPI) communication systems LPI sensors Tactical UAV

Inadequacies in the area of weapon employment include the inability to satisfy the simultaneous need for sensor information; the limited ability of some sensors to acquire and track multiple targets; inadequate coordination of sensor information among battle managers; lack of an all-weather/day-night precision (<3-meter CEP) weapon capability; insufficient weapon ranges (standoff) and long weapon time of flight to target (time critical); sortie efficiency for attacks against hard, buried, and strategic targets; GPS jamming; and more affordable precision-guided munitions as well as more affordable, reliable, survivable attack aircraft. Littoral warfare, quieter submarines, improved threat air defense, and ground forces require advancements in air/sea/land superiority and defense.

Deficiencies confronting combat assessment revolve around timeliness (either real time or near-real time rather than the current capability of several hours) and accuracy. A major challenge is to counter an adversary's camouflage, concealment, and physical/electronic deception techniques to obtain accurate battle damage assessments and to measure weapon effectiveness.

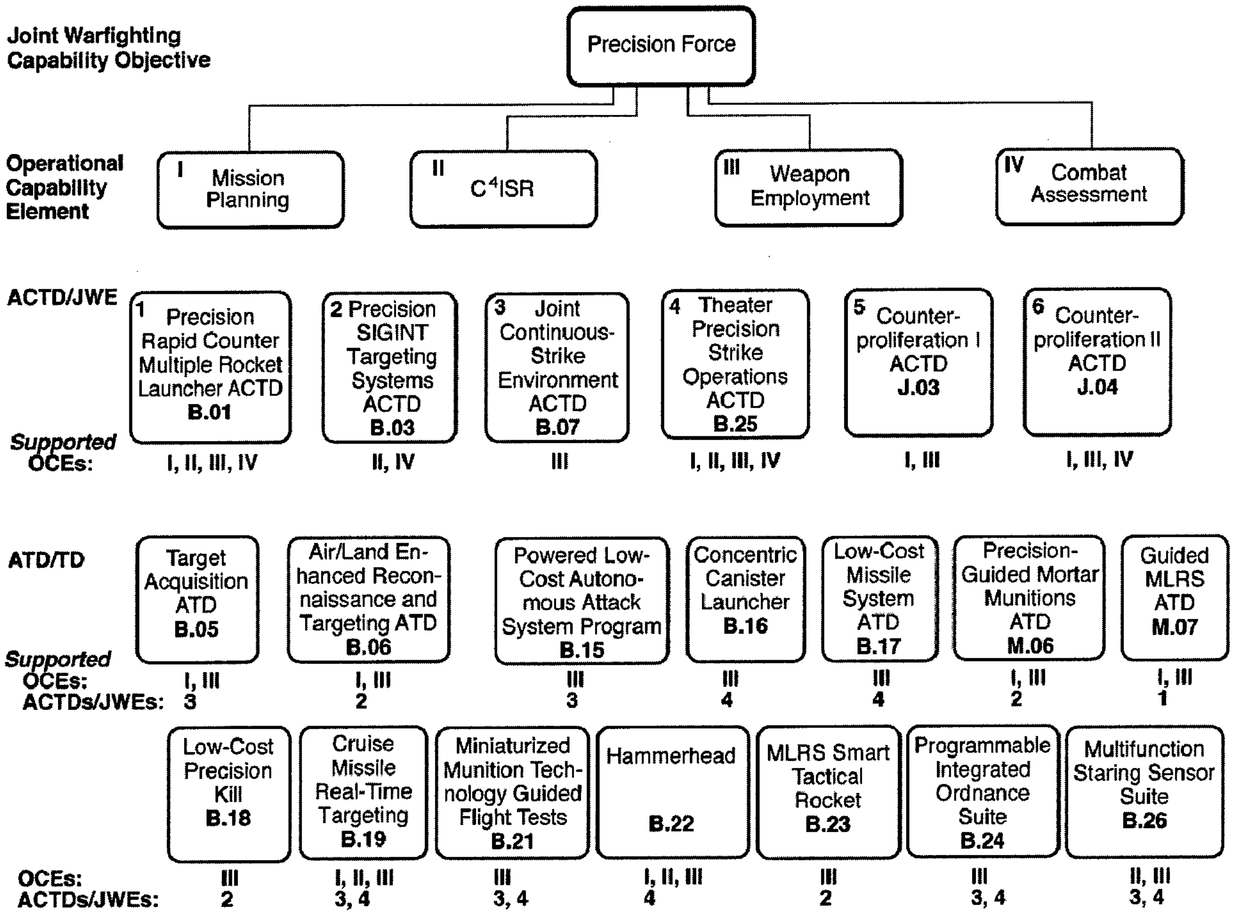
Shortcomings in C^4I focus on two trends. First is the need to handle ever-increasing amounts of information more quickly than ever before. Second is the steady integration of C^4I functions into a modular "system-of-systems" architecture that maximizes information availability and aids the planners and warfighters in making the most effective use of that information. The ability to conduct rapid, accurate target identification and selection requires substantial development, as does the ability to follow up attacks with comprehensive combat assessments. Technology that will facilitate the completion of real-time, collaborative planning both in the area of operations and at distributed staff locations must be a priority. To support planning improvements, staff and commanders need to be able to track force status and execution. Rapid, precise strike planning will be improved by the development of a capability to quickly pair mission requirements, target locations, and physical characteristics to weapon delivery systems. The capability to better manage and integrate intelligence, surveillance, and reconnaissance analysis will enhance development of the precision force concept. The automatic target/weapon pairing developed during the Precision Force ACTDs—PRCMRL (B.01), PSTS (B.03), JCSE (B.07) and TPSO (B.25)—will definitely enhance the U.S. ability to conduct Precision Force missions.

E. TECHNOLOGY PLAN

The science and technology program to correct the deficiencies in mission planning, weapon employment, combat assessment, and C^4ISR is shown in Figure V–3. These technologies offer the potential for a significant increase in today's capability. Their need is underscored by our experience in Operation Desert Storm.

Table V–3 identifies the joint warfighting Precision Force DTOs. Definitions, points of contact, and funding profiles for the Precision Force DTOs are provided. Table V–4 shows the DTOs that, when attained, will enable the operational capability elements. The schedule for achieving the DTOs is presented in the technology roadmap in Figure V–4. This roadmap represents activities in mission planning, weapon employment, combat assessment, and C^4ISR.

The technology efforts include projects in the Army, Air Force, Navy, Marine Corps, DARPA, and the DSWA S&T program. Below is a list of the efforts by DTO:



Supporting DTAP DTOs

AP.10.00	Cruise Missile/Expendable Propulsion
AP.17.00	Hydrocarbon Scramjet Missile Propulsion
HS.12.02	Helmet-Mounted Sensory Ensemble
IS.47.01	Command Post of the Future
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing
SE.09.02	Multiwavelength, Multifunction Laser
SE.13.02	Lightweight, Broadband, Variable-Depth Sonar
SE.14.02	Multistatic Active Antisubmarine Warfare
SE.33.01	Advanced Focal Plane Array Technology
SE.59.01	Low-Light-Level Imaging Sensors
SE.61.01	Multiphenomenology Sensor Fusion for ATR and Tracking
SE.62.02	LADAR ATR for Conventional Weapons
WE.12.02	Antijam GPS Flight Test
WE.18.02	Direct-Fire Lethality ATD
WE.21.02	Fiber-Optic, Gyro-Based Navigation Systems
WE.29.02	Antitorpedo Torpedo
WE.32.02	Broadband Torpedo Sonar Demonstration
WE.35.02	Air Superiority Missile Technology
WE.39.02	Tactical Solid-Rocket Missile Propulsion
WE.45.07	Sea Mines
WE.54.02	Reactive Material Warhead ATD
WE.55.02	Reduced-Size Torpedo Subsystem Demonstration
WE.57.02	Lethality/Vulnerability Models for High-Value Fixed Targets
WE.58.02	Microelectromechanical Systems Inertial Navigation System
WE.59.02	Hypersonic Weapons Technology Demonstration

Figure V–3. Technology to Capability—Precision Force

Table V–3. Defense Technology Objectives—Precision Force

DTO No.	Title
B.01	Precision Rapid Counter Multiple Rocket Launcher ACTD
B.03	Precision Signals Intelligence Targeting Systems ACTD
B.05	Target Acquisition ATD
B.06	Air/Land Enhanced Reconnaissance and Targeting ATD
B.07	Joint Continuous-Strike Environment ACTD
B.15	Powered Low-Cost Autonomous Attack System Program
B.16	Concentric Canister Launcher
B.17	Low-Cost Missile System ATD
B.18	Low-Cost Precision Kill
B.19	Cruise Missile Real-Time Retargeting
B.21	Miniaturized Munition Technology Guided Flight Tests
B.22	Hammerhead
B.23	MLRS Smart Tactical Rocket
B.24	Programmable Integrated Ordnance Suite
B.25	Theater Precision Strike Operations ACTD
B.26	Multifunction Staring Sensor Suite
J.03	Counterproliferation I ACTD
J.04	Counterproliferation II ACTD
M.06	Precision-Guided Mortar Munitions ATD
M.07	Guided MLRS ATD
AP.10.00	Cruise Missile/Expendable Propulsion
AP.17.00	Hydrocarbon Scramjet Missile Propulsion
HS.12.02	Helmet-Mounted Sensory Ensemble
IS.47.01	Command Post of the Future
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing
SE.09.02	Multiwavelength, Multifunction Laser
SE.13.02	Lightweight, Broadband, Variable-Depth Sonar
SE.14.02	Multistatic Active Antisubmarine Warfare
SE.33.01	Advanced Focal Plane Array Technology
SE.59.01	Low-Light-Level Imaging Sensors
SE.61.01	Multiphenomenology Sensor Fusion for ATR and Tracking
SE.62.02	LADAR ATR for Conventional Weapons
WE.12.02	Antijam GPS Flight Test
WE.18.02	Direct-Fire Lethality ATD
WE.21.02	Fiber-Optic, Gyro-Based Navigation Systems

Table V–3. Defense Technology Objectives—Precision Force

DTO No.	Title
WE.29.02	Antitorpedo Torpedo
WE.32.02	Broadband Torpedo Sonar Demonstration
WE.35.02	Air Superiority Missile Technology
WE.39.02	Tactical Solid-Rocket Missile Propulsion
WE.45.07	Sea Mines
WE.54.02	Reactive Material Warhead ATD
WE.55.02	Reduced-Size Torpedo Subsystem Demonstration
WE.57.02	Lethality/Vulnerability Models for High-Value Fixed Targets
WE.58.02	Microelectromechanical Systems Inertial Navigation System
WE.59.02	Hypersonic Weapons Technology Demonstration

Table V–4. Demonstration Support—Precision Force

	Operational Capability Elements						Type of Demonstration	
Demonstration	Mission Planning	C^4ISR	Weapon Employment	Combat Assessment	Service/ Agency	DTO	ACTD	ATD
Precision Rapid Counter Multiple Rocket Launcher ACTD	●	●	●	●	Joint	B.01	X	
Precision Signals Intelligence Targeting Systems ACTD		●		●	Navy	B.03	X	
Target Acquisition ATD	●		●	○	Army	B.05		X
Air/Land Enhanced Reconnaissance and Targeting ATD	●	○	●	○	Army	B.06		X
Joint Continuous-Strike Environment ACTD			●		Joint	B.07	X	
Powered Low-Cost Autonomous Attack System Program	○		●		Air Force	B.15		X
Concentric Canister Launcher	○		●		Navy	B.16		X
Low-Cost Missile System ATD	○		●		Navy	B.17		X
Low-Cost Precision Kill	○		●		Army	B.18		
Cruise Missile Real-Time Retargeting	●	●	●	○	Navy	B.19		X
Miniaturized Munition Technology Guided Flight Tests	○		●		Air Force	B.21		X
Hammerhead	●	●	●		Air Force	B.22		
MLRS Smart Tactical Rocket	○		●		Army	B.23		
Programmable Integrated Ordnance Suite			●		Air Force	B.24		
Theater Precision Strike Operations ACTD	●	●	●	●	Joint	B.25	X	
Multifunction Staring Sensor Suite		●	●	○	Army	B.26		X
Counterproliferation I ACTD	●		●	○	DSWA	J.03	X	
Counterproliferation II ACTD	●		●	●	DSWA	J.04	X	

● Strong Support ○ Moderate Support (P) Proposed

Table V–4. Demonstration Support—Precision Force (continued)

Demonstration	Operational Capability Elements: Mission Planning	C4ISR	Weapon Employment	Combat Assessment	Service/ Agency	DTO	Type of Demonstration: ACTD	ATD
Precision-Guided Mortar Munitions ATD	●		●		Army	M.06		X
Guided MLRS ATD	●		●		Army	M.07		X
Cruise Missile/Expendable Propulsion	○	●	●	●	Joint	AP.10.00		
Hydrocarbon Scramjet Missile Propulsion	●		●		Air Force	AP.17.00		
Helmet-Mounted Sensory Ensemble	○	○	○		Air Force, Navy	HS.12.02		
Command Post of the Future	●	●	○	●	DARPA	IS.47.01		
Multifunction Electro-Optical Sensors and Signal Processing		●	○	●	Joint	SE.06.01		
Multiwavelength, Multifunction Laser		●	○	●	Joint	SE.09.02		
Lightweight, Broadband, Variable-Depth Sonar		●	○	●	Navy	SE.13.02		
Multistatic Active Antisubmarine Warfare		●	●	●	Navy	SE.14.02		
Advanced Focal Plane Array Technology	●	●	●	●	Joint	SE.33.01		
Low-Light-Level Imaging Sensors	○	●	●	●	Joint	SE.59.01		
Multiphenomenology Sensor Fusion for ATR and Tracking	●	●	●	●	Joint	SE.61.01		
LADAR ATR for Conventional Weapons	●		●		Joint	SE.62.02		
Antijam GPS Flight Test	●		●		Air Force	WE.12.02		
Direct-Fire Lethality ATD		○	●		Army	WE.18.02		X
Fiber Optic, Gyro-Based Navigation Systems	○		●		DARPA, Navy	WE.21.02		
Antitorpedo Torpedo	○		●	●	Navy	WE.29.02		X
Broadband Torpedo Sonar Demonstration	○		●	○	Navy	WE.32.02		
Air Superiority Missile Technology	○		●		Air Force	WE.35.02		
Tactical Solid-Rocket Missile Propulsion	○		●		Joint	WE.39.02		
Sea Mines			●		Navy	WE.45.07		
Reactive Material Warhead ATD	○		●		Navy	WE.54.02		X
Reduced-Size Torpedo Subsystem Demonstration			●		Navy	WE.55.02		
Lethality/Vulnerability Models for High-Value Fixed Targets	●				Joint	WE.57.02		
Microelectromechanical Systems Inertial Navigation System	●	○	●		DARPA	WE.58.02		
Hypersonic Weapons Technology Demonstration	●		●		Navy	WE.59.02		

● Strong Support ○ Moderate Support (P) Proposed

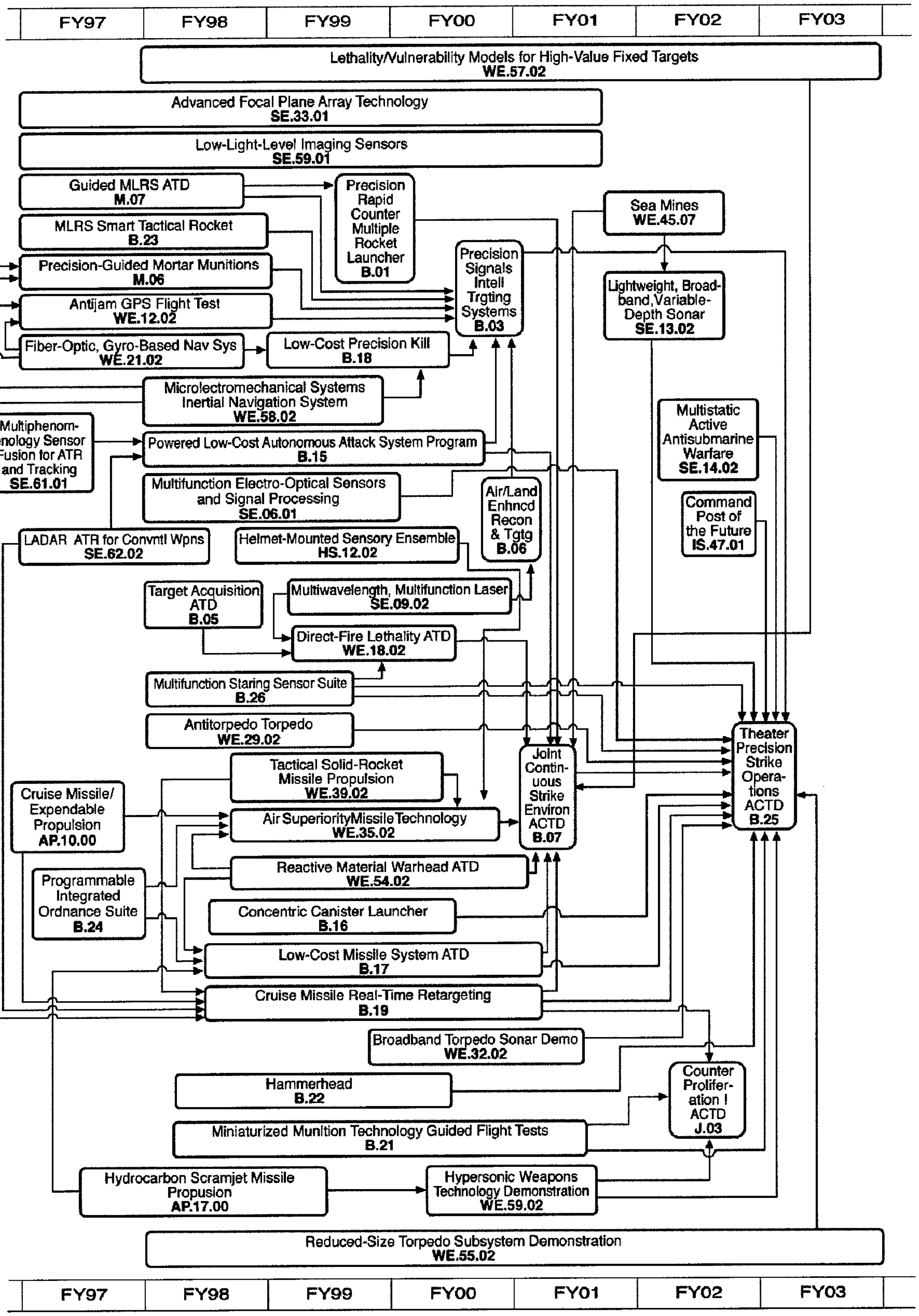


Figure V–4. Roadmap—Precision Force

- *B.01, Precision Rapid Counter Multiple Rocket Launcher (PRCMRL) ACTD,* developed and demonstrated a joint, adverse-weather, day/night, end-to-end, sensor-to-shooter, precision deep-strike capability to locate, identify, and kill high-value, short-dwell, time-sensitive targets and assess damage within tactically meaningful timelines.

- *B.03, Precision SIGINT Targeting Systems (PSTSs) ACTD,* is an effort to develop and demonstrate a near-real-time, precision targeting, sensor-to-shooter capability using existing national and tactical assets.

- *B.05, Target Acquisition (TA) ATD,* will provide the warfighter a system for night or poor-visibility usage that will offer knowledge of the battlespace in real time and will improve light/armored combat vehicle lethality and survivability.

- *B.06, Air/Land Enhanced Reconnaissance and Targeting (ERT) ATD,* will provide the helicopter pilot/gunner the ability to automatically acquire and identify stationary and moving targets from an on-the-move, high-speed aerial platform such as a scout/attack helicopter.

- *B.07, Joint Continuous-Strike Environment (JCSE) ACTD,* will optimize the use of air-, land-, and sea-based weapons to prosecute time-sensitive surface targets within their cycle times. It will continuously update target priorities, assess weapon status, match weapon(s) to targets, and ensure execution by deconflicting airspace.

- *B.15, Powered Low-Cost Autonomous Attack System (LOCAAS) Program,* will demonstrate and integrate advanced laser radar (LADAR) sensor technology in combination with a multimode warhead and advanced submunition airframe.

- *B.16, Concentric Canister Launcher ATD,* will demonstrate the feasibility of a universal launching system employing concentric canisters that can be applied to future combat ships capable of firing a wide range of missiles, including ESSM, Tomahawk, Standard Missile Block IV, and the ATACMS.

- *B.17, Low-Cost Missile ATD,* will demonstrate a unique, finless, low-drag, bending annular missile body (BAMB) airframe and ramjet propulsion concept that will provide the capability to attack time-critical and hardened targets in a timely and affordable manner.

- *B.18, Low-Cost Precision Kill (LCPK),* will demonstrate a very low cost, accurate guidance and control retrofit package for the 2.75-inch Hydra–70 rocket. This rocket will provide a standoff capability against specified nonheavy armor targets, which are often engaged in large numbers.

- *B.19, Cruise Missile Real-Time Retargeting,* will develop technologies for brilliant autonomous missiles that have onboard mission planning and control systems.

- *B.21, Miniaturized Munition Technology (MMT) Guided Flight Tests,* will provide the Air Force with a 250-pound smart weapon capable of defeating 85 percent of the Joint Direct Attack Munition (JDAM) MK83/BLU–109–2010 fixed- and hard-target threats. It offers increased loadout of existing bombers and smaller weapon bay requirements for future aircraft.

- *B.22, Hammerhead,* will demonstrate a JDAM-class synthetic aperture radar seeker for guided applications with a capability to strike fixed targets obscured by clouds or foggy conditions.
- *B.23, MLRS Smart Tactical Rocket,* will demonstrate the feasibility of deploying smart submunitions for a Multiple Rocket Launcher System (MLRS) rocket.
- *B.24, Programmable Integrated Ordnance Suite,* will develop and demonstrate an integrated ordnance suite composed of an imaging infrared target detection device, advanced initiation fireset, and directional warhead to maximize medium- and short-range missile counter air lethality.
- *B.25, Theater Precision Strike Operations ACTD,* will develop and demonstrate a significantly improved capability for the Ground Component Commander (GCC) to forecast, plan, and execute deep operations with an integrated joint and coalition force to detect volume of fires, plan collaborative targeting, and direct counterfire and precision engagements against all types of ground targets using joint/coalition assets.
- *B.26, Multifunction Staring Sensor Suite,* will demonstrate a sensor system capable of acquiring and identifying targets beyond the range of the host platform weapon systems. In addition to the target acquisition functions, the host platform must perform supplementary tasks such as sensing target range, acquiring fleeting targets, and locating sources of sniper and mortar fires.

The PRCMRL (B.01) and PSTS (B.03) ACTDs address deficiencies in the four precision force operational capability elements. The JCSE (B.07) and TPSO (B.25) ACTDs demonstrate the seamless battlespace environment provided by the digitized C^4ISR capability. The JCSE goals must be achieved to demonstrate a precision force joint engagement capability, while the TPSO goals will be needed to win quick, decisive battles against any future adversary.

The ATDs and supporting key technology efforts are advancing work on data fusion and combining ATR technologies with precision location so that weapons can find the types of target specified, or even the particular target specified, and guide a weapon to within a few feet of a designated impact point. Other initiatives to destroy time-critical targets will demonstrate the capability to redirect missiles and attack aircraft while on a mission so as to exploit real-time retargeting.

A major focus is demonstration of GPS applications to both existing and new weapons. Examples include a Navy effort to demonstrate an inexpensive cruise missile and an Air Force effort to develop small smart bomb technology. The Air Force Miniaturized Munition Technology Guided Flight Test will demonstrate dramatically improved sortie efficiency for attacks against all but the very hardest fixed targets. Another flight demonstration by the Air Force, called Antijam GPS Technology Flight Test (AGTFT), will demonstrate an affordable solution for protecting against an enemy jamming a GPS guided munition. This technology will be demonstrated on a JDAM vehicle in FY98.

The Army Guided MLRS program will increase the accuracy of the Extended-Range MLRS rocket to a 3-mil system. The BAT Preplanned Product Improvement (BAT P^3I) will be delivered by the Army TACMS Block II, extended-range Block IIa, and MLRS. BAT P^3I employs acoustic, millimeter-wave, and imaging infrared (IIR) seekers while expanding the BAT target set to include cold, stationary armor, moving armor, SSMs, and MRLs. It includes a selectable warhead that will

be switched to the hard or soft target mode prior to impact. The Air Force and Army are jointly pursuing another antimateriel munition called LOCAAS, which uses a LADAR seeker to search, identify, and track ground mobile targets and attack with a multimode warhead. LOCAAS is being designed for delivery by MLRS and by Air Force fighter and bomber aircraft.

The Air Force is also developing an expanded, more capable air command and control network based on the air operations center, but distributed to the Airborne Command and Control Centers, the Airborne Warning and Control System, and the Joint Surveillance Target Attack Radar System. These systems receive tactical information from their own sensors and from other intelligence platforms and processing systems. They can rapidly direct combat elements to air superiority, ground attack, or interdiction missions.

F. SUMMARY

The collective capability demonstrated for each DTO scheduled between 1998 and 2004 shows a stepped improvement in operational capability over the previous demonstrations. The capabilities and schedule of availability are depicted in Figure V–5. Integration of the DTOs over time will provide a greater ability to accurately locate, identify, and destroy all classes of high-value and time-critical targets with precision while limiting collateral damage, thus realizing Precision Force and contributing to the realization of Precision Engagement.

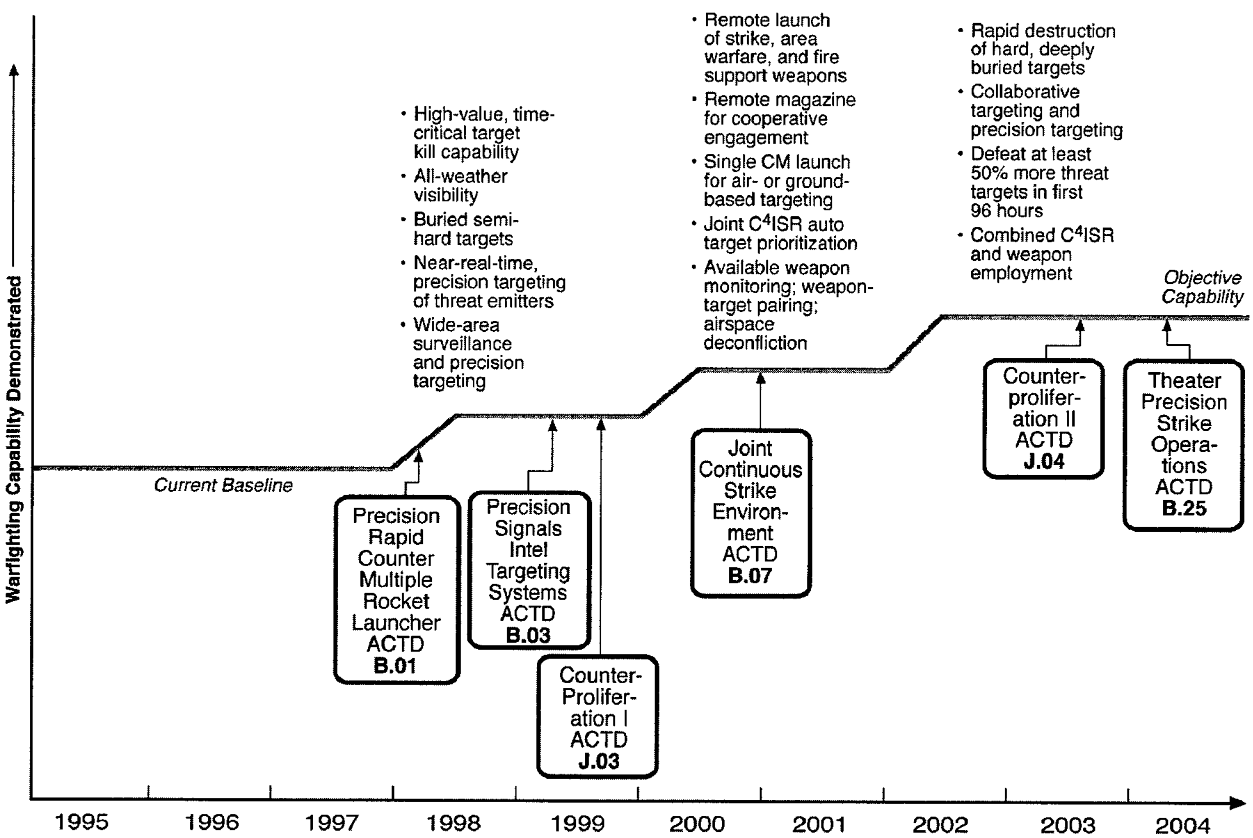


Figure V–5. Progress—Precision Force

CHAPTER VI

COMBAT IDENTIFICATION

CHAPTER VI
COMBAT IDENTIFICATION

A. DEFINITION

Combat Identification (CID) is defined as the process of attaining an accurate characterization of entities in a combatant's area of responsibility to the extent that high-confidence, real-time application of tactical options and weapon resources can occur. The objective of CID is to maximize combat/mission effectiveness while reducing total casualties (due to enemy action and fratricide).

B. OPERATIONAL CAPABILITY ELEMENTS

U.S. forces must be able to positively identify all targets in the battlespace for all combat mission areas—air to air, air to surface, surface to surface, and surface to air. Surface includes land, sea, and subsurface—otherwise known as ground and maritime (Figure VI–1). The CID need is essential in order for commanders to effectively field, at any time, fighting forces that can rapidly and positively identify enemies, friends, and neutrals in the battlespace; manage and control the battle area; optimally employ weapons and forces; and minimize total casualties.

In 1992, the Joint Requirements Oversight Council (JROC) validated the Joint Mission Need Statement (MNS), which defines the broad-based requirements for CID. These include positive, timely, and reliable identification of friends, foes, and neutrals; classification of foes by class, type, and nationality; and interoperability required among the U.S. military and desired with allied

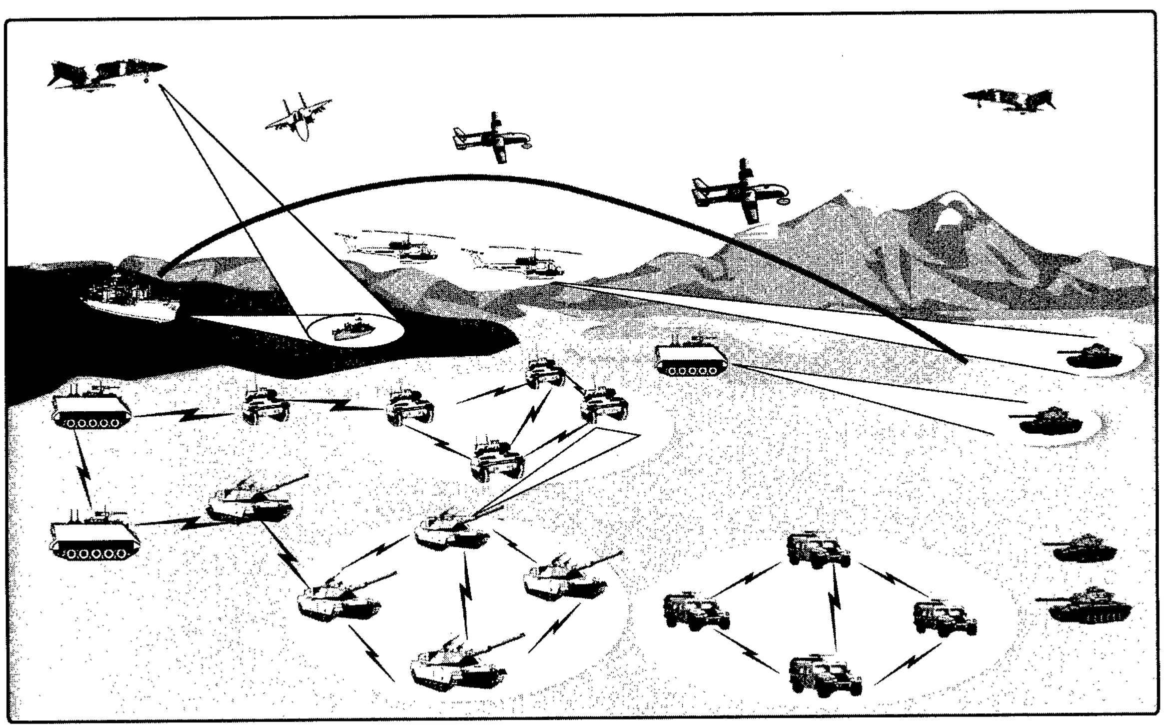


Figure VI–1. Concept—Combat Identification

nations. The challenges presented by the requirements necessitate a CID architecture that blends both nonmateriel and materiel solutions.

Nonmateriel solutions include doctrine; tactics, techniques, and procedures (TTP); and training. From a cost perspective, the nonmateriel solution to resolving a CID deficiency is compelling if it does not carry untenable constraints on the warfighter. However, nonmateriel solutions often need to be augmented by materiel solutions. These can be characterized as cooperative/noncooperative sensor systems and command, control, and communications (C^3) systems—in particular, digital datalinks and radios, each of which contributes a portion to the CID solution. As such, CID is viewed as a capability, not a single system or program. A "system-of-systems" approach is required.

CID is the result of a process that appropriately and accurately characterizes the entities present in a combatant's area of responsibility. Effective CID can take place with varying degrees of target identification, depending on the conditions of the battlespace. At times, the extent of required identification is only to rapidly distinguish among friendly, neutral, and adversary forces with high enough confidence to support weapon employment decisions. At other times, identification of target class (e.g., cruise missile, fighter, or bomber) or target recognition (e.g., target vs. decoy) is required to select the correct defensive or offensive tactical weapon response. In other cases, a more extensive characterization that identifies specific target parameters, such as platform type (e.g., MiG–29 vs. MiG–21) and intent (e.g., an active interceptor vs. a defector) is required to select optimal defensive weapons and to support weapon release decisions. In all cases, the goal for CID is to provide the necessary level of identification to make correct weapon decisions. This CID approach supports the attainment of military objectives while minimizing total casualties.

The primary objective for CID is to correlate and assign a foe, friend, or neutral identification label to a "target." The identification label can be assigned at any time from initial detection of the potential target to weapon employment. To be useful for a direct-fire engagement, the correct target label must be correlated to a sensor return that is in a "weapon sight" (e.g., radar, laser, or thermal sight). Indirect-fire weapons or supporting fire weapons operate from a different perspective as they cannot "see" the target. The identification is made and sent to the weapon by the fire requestor or a surveillance/reconnaissance platform; the weapon is correlated to the specified target position.

As discussed earlier, there are two classes of materiel solutions:

- *Sensors*—the target is characterized either noncooperatively (e.g., radar signal modulation, high-range resolution radar, or electronic support measures) or cooperatively (e.g., MK XII identification friend or foe (IFF) system or Battlefield Combat Identification System (BCIS)).
- *C^3 (particularly digital datalinks and radios)*—the target declares (either periodically or when queried) its identification and position in a reference frame that the "shooter" can correlate with its own weapon and sensor system (e.g., Link–16).

Both approaches have their strengths and limitations. If the identification is determined by an offboard sensor, there is the added necessity to pass and correlate the required information in a timely fashion. This requirement to correlate an identification label with a sensor return in the "weapon sight" is a key discriminator and a source of significant cost for the systems.

The vision is a fielded CID capability that ensures that all combatant platforms will have available the required identification information in a timely fashion that is commensurate with the range and lethality of the platforms' weapons and sensors. The approach toward realizing this vision is through an integrated CID architecture that combines noncooperative and cooperative identification sensors and systems with C^3 (particularly digital datalinks and radios) capabilities. Such an architecture supports the development of situational awareness—the overall, general knowledge of the tactical battlefield environment, including the location of friendly, neutral, and enemy forces as well as the plan of action for battle. The required operational capability will then be achieved by combining onboard data from multiple sensors and systems with indirectly supplied offboard information.

Due to the fundamental differences of their operating environments, the operational capability elements can be aggregated into three categories: air, ground, and maritime target platforms. Air platforms are more dispersed, move at much higher speeds, and are engaged at relatively long ranges with imaging or nonimaging sensors. Ground platforms are closely spaced, move slowly, and are engaged at close ranges with imaging sensors. Maritime platforms are relatively slow compared with air platforms, can be either closely spaced (several hundreds of yards) or more dispersed (several nautical miles), and are engaged at longer ranges than ground platforms due to the nonimaging sensors indigenous to the maritime platform or the imaging/nonimaging sensors of the aircraft attached to the maritime unit.

In general, the current CID capability against all platforms must be improved. The current CID capability in many cases does not allow for maximum use of a weapon's range and engagement of targets in highly mixed, fast-moving environments. The result is that combat effectiveness is often restricted by confining rules of engagement and procedures.

For ground targets (air-to-surface and surface-to-surface mission areas), the current capability is extremely limited. The plan is to have an initial level of high-confidence CID capability fielded for all early-deploying, first-line combatant platforms within 10 years. The CID capability must provide the required identification information with very high confidence.

For air targets (surface-to-air and air-to-air mission areas) as well as maritime targets (surface-to-surface and air-to-surface mission areas), CID needs improvement in some areas. In some cases, effective systems have been developed that could fill some of the needs but are not widely fielded. In other cases, noncooperative sensor/technique databases need to be updated and more fully populated. In still other areas, correlation/fusion issues need to be resolved. The objective is to provide nearly perfect identification information.

Automatic target recognition (ATR) pertains to the implementation of cooperative and noncooperative sensor systems. The need for ATR systems stems from the increased complexity of tactical and strategic battlespaces, the unprecedented amount of raw information produced by modern sensor systems, and the effectiveness of C^3 systems. Collectively these can overwhelm the capability of human operators and decision makers. The magnitude and rate of information produced may exceed the operator's ability to absorb and process it in a timely fashion; performance declines with operator fatigue and varies with operator training. Consequently, ATR systems are being developed to provide an assortment of technological services that range from operator prompting (cueing) tools to fully automated ATR systems requiring no human operator intervention.

More precisely, the goal of ATR is to support rapid and reliable detection, geolocation, tracking, recognition, and prioritization of targets. In general, the output will provide a human operator or decision maker with target recommendations, weapon options, and the level of confidence associated with each proposed action.

The degree to which the constituent functions can or should be automated depends not only on the efficacy of the ATR technology but also on sensor performance, target complexity and density, target environment, mission requirements, and required response times. For example, particular mission or battlespace conditions may only require an ATR system to sort through a very large potential target density and alert an operator to the presence and location of a change in battlespace conditions (e.g., deployment of troop positions or bomb damage assessment) since the previous battlespace analysis. In this example, image analysts would be required to infer appropriate information from the data; such systems, which are predicated on active human participation, are sometimes referred to as *assisted target recognition* or *aided target recognition.*

In summary, ATR provides enabling technologies for CID. The amount of automation that can be provided by ATR relates to the varying degrees of target identification required for a functional CID capability. For additional information on ATR, see *Defense Technology Area Plan,* Chapter VII, Sensors, Electronics, and Battlespace Environment.

C. FUNCTIONAL CAPABILITIES

The functional capabilities for CID include foe identification (including platform type, class, nationality, allegiance, and intent information), friend identification, neutral identification, and interoperability (for cooperative sensors, C^3 datalinks/radios, and databases on noncooperative sensors and techniques). The functional capabilities required to meet the CID operational capability elements and the strength of their support (in terms of efforts spent and focus of technological and programmatic activities) are shown in Table VI–1. The relative importance of these functional capabilities to the operational capability elements varies due to the fundamental differences in the missions and the operating environments of the potential targets.

Table VI–1. Functional Capabilities Needed—Combat Identification

	Operational Capability Elements			
Functional Capabilities	Air to Surface	Surface to Surface	Surface to Air	Air to Air
1. Foe Identification	●	○	●	●
2. Friend Identification	●	●	●	●
3. Neutral Identification	●	○	●	●
4. Interoperability	●	●	●	●

● Strong Support ○ Moderate Support

Noncooperative identification sensors and systems have the advantage of identifying foes, friends, and neutrals. Cooperative identification sensor systems, which only identify friendly units, have the advantage of less technical challenge; however, they require all friendly potential targets to be equipped with the same corresponding identification equipment. C^3 systems (particularly digital datalinks and radios) are also cooperative systems that provide (1) friend identification automatically (for all participants on the network), (2) a medium for passing hostile/neutral identification generated from other sensors/sources, and (3) a medium for passing friend identification (for those platforms not on the network) generated from other sensors/sources. In addition to doctrine/TTP, all of these systems are critical contributors to a system-of-systems approach in providing both situational awareness and identification to use lethal weapons in the battlespace. The functional capabilities of all CID systems must work synergistically to provide a robust, high-confidence CID capability.

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

The U.S. baseline varies according to operational capability element mission area. Some technological capabilities have not been fielded while others have only been fielded to a small segment of the force.

Current Air-to-Surface Capability

Foe Identification

- Visual identification.
- Use of tactical reconnaissance or surveillance aircraft to exploit electronic signals emitted by a set of targets (e.g., electronic support measures (ESM)).
- Recognition of classes of maritime platforms using inverse synthetic aperture radar (ISAR).
- Recognition of classes of ground platforms using synthetic aperture radar (SAR).
- Communication by ground or air forward air controller (FAC)—via voice or automated ground target information passing systems (e.g., Improved Data Modem or Automatic Target Handoff System)—for close air support (CAS) information, including target location and identification, nearest friendly position, and clearance to drop ordnance.

Friend Identification

- Visual identification.
- Use of marking schemes for ground platforms that can be readily detected visually or via available sensors.
- Query and identification of maritime platforms with cooperative sensor/C^3 system (e.g., MK XII Mode 4 or Link–16, the latter still being fielded).

Neutral Identification

- Visual identification only.

Interoperability

- Voice communications.
- Query and identification of maritime platforms with cooperative sensor/C^3 system (e.g., MK XII Mode 4 or Link–16, the latter still being fielded).

Current Surface-to-Surface Capability

Foe Identification

- Visual identification of ground and maritime platforms.
- Classification of maritime platforms via radar returns, exploiting electronic signals emitted by target (e.g., ESM).

Friend Identification

- Visual identification of ground and maritime platforms.
- Query and identification of potential targets with cooperative sensor/C^3 system (e.g., for ground platforms, the Battlefield Combat Identification System, in limited numbers; for maritime platforms, the MK XII Mode 4 or Link–16).
- Use of marking schemes for ground platforms that can be readily detected visually or via available sensors.
- Classification of maritime platforms via radar returns, exploiting electronic signals emitted by target (e.g., ESM).
- Improved location of friendly ground forces using Global Positioning System (GPS).

Neutral Identification

- Visual identification of ground and maritime platforms.
- Classification of maritime platforms via radar returns, exploiting electronic signals emitted by target (e.g., ESM).

Interoperability

- Voice communications.
- General location of friendly ground battle participants based on tactical digital radios, which are still being fielded, have mixed levels of interoperability, and are not yet based on joint common data element standards.
- Location of friendly maritime battle participants based on digital datalinks (e.g., legacy Link–11 and current/future Link–16), which have mixed levels of interoperability.

Current Surface-to-Air Capability

Foe Identification

- Visual identification.
- Classification of platform type via detailed analysis of radar return (e.g., radar signal modulation (RSM), radar painting).

- Exploitation of electronic signals emitted by target (e.g., ESM).

Friend Identification

- Visual identification.
- Query and identification of potential targets with cooperative sensor/C^3 system (e.g., MK XII Mode 4 or Link–16).
- Classification of platform type via detailed analysis of radar return (e.g., RSM, radar painting).
- Exploitation of electronic signals emitted by targets (e.g., ESM).

Neutral Identification

- Visual identification.
- Classification of platform type via detailed analysis of radar return (e.g., RSM, radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Interoperability

- Big picture of battlespace via Link–16 and other legacy datalinks that are not yet interoperable across services.
- Voice communications with other agencies and sensors.

Current Air-to-Air Capability

Foe Identification

- Visual identification.
- Classification of platform type via detailed analysis of radar return (e.g., RSM, radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Friend Identification

- Visual identification.
- Query and identification of potential targets with cooperative sensor/C^3 system (e.g., MK XII Mode 4 or Link–16).
- Classification of platform type via detailed analysis of radar return (e.g., RSM, radar painting).
- Exploitation of electronic signals emitted by target (e.g., ESM).

Neutral Identification

- Visual identification.
- Classification of platform type via detailed analysis of radar return (e.g., RSM, radar painting).

- Exploitation of electronic signals emitted by target (e.g., ESM).

Interoperability

- Big picture of battlespace via Link–16 and other legacy datalinks that are not yet interoperable across services.
- Voice communications with other agencies and sensors.

Addressing the issue of C^3/digital datalink and radio interoperability, the United States is migrating toward a J-series family of datalinks to include Link–16 for air operations, Link–22 for maritime operations, and variable message format (VMF) for ground operations. All datalinks/ digital radios are to comprise J-series (TADIL–J–based) protocols and message sets to facilitate communications across the battlespace. For air, maritime, and ground weapons, doctrine/TTP plays a significant role in sorting friend from foe or neutral in the battlespace.

The JROC has reviewed the CID joint warfighting needs by mission areas and has stated a need for CID in all mission areas. Additionally, the JROC ranked the mission areas in terms of available CID equipage from the most deficient to the least deficient as follows:

- Air to surface
- Surface to surface
- Surface to air
- Air to air.

The JROC noted that many U.S. platforms are currently deficient in CID systems and datalinks. No ground combatants have a long-range identification capability, and many maritime and air platforms have only limited CID suites.

There are two principal barriers to having universal CID capability on all air, maritime, and ground platforms: affordability and signature exploitability.

Affordability. The costs of CID suites that are properly integrated with the weapon sight (both cooperative and noncooperative) are usually prohibitive if they are not a P^3I of an existing sensor or system. Additional functionality in the form of intelligence, communications, situational awareness, or sensing/detection is helpful in making CID more affordable as it is being used to meet numerous other operational needs and objectives. The affordability of a system will also vary significantly depending on the environment in which it is considered. Aviation/maritime systems are generally more expensive than ground-based systems, especially in the area of platform integration. Leveraging planned or programmed platform modification of other systems onto platforms shares the integration costs with other programs, thereby making the total bill lower and the net and delta CID cost lower. Alternatively, for ground combat vehicles, although system and integration costs are appreciably lower, there are many more platforms involved, so the total cost can also be prohibitively expensive if system costs are not held to a minimum. Technology that eases the integration overhead of a CID-related system or reduces its component cost is required.

Signature Exploitability. Noncooperative techniques of identification are most attractive to warfighters due to their ability to generate labels for foe, friend, and neutral contacts, and because they can provide additional identification information on adversaries (e.g., platform type, class,

nationality). For air/maritime targets, the current capabilities of these systems are limited in range, aspect, and timeliness of reporting. The result is that the indications from this class of systems are frequently in the "unknown" or "not available" state. Improvements in sensors and target databases that expand the envelope of performance for these systems are necessary. For combat vehicles, the signal environment is such that reliable identification at maximum weapon range remains a significant technical challenge. Limitations in sensor resolution—coupled with variations in target aspect, state, countermeasures, and the battlespace signal propagation environment—complicate the job of target labeling. Technology improvements for improved sensors and ATR that can interpret imaging and nonimaging sensor data to reliably identify the platform type are necessary. The key technologies for reaching the combat identification joint warfighting capabilities are shown in Table VI–2. Several Defense Technology Objectives (DTOs) in the Sensors, Electronics, and Battlespace Environment area of the DTAP also support Combat Identification. These include Multifunction Electro-Optical Sensors and Signal Processing (SE.06.01), Affordable ATR via Rapid Design, Evaluation, and Simulation (SE.19.03), Advanced Radar Processing From Airborne Platforms (SE.03.01), Automatic Target Recognition for Reconnaissance and Surveillance (SE.20.01), Multiwavelength, Multifunction Laser (SE.09.02), and Advanced Focal Plane Array Technology (SE.33.01).

Table VI–2. Goals, Limitations, and Technologies—Combat Identification

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Air to Surface			
Robust, high-confidence ID capability at range commensurate with range and lethality of weapons Maximum military effectiveness of combatants Minimum total casualties due to enemy action and fratricide Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperability Secure operations Nonexploitability	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) CC&D Lack of standardized datalink Affordability Vulnerability	Fusion Database management Moving surface target imaging radar Radar imaging/processing Laser development/processing IR focal plane array Advanced IR sensors ESM Secure datalinks ATR development Target phenomenology and modeling

Table VI–2. Goals, Limitations, and Technologies—Combat Identification (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Surface to Surface			
Robust, high-confidence ID capability at range commensurate with range and lethality of weapons Maximum military effectiveness of combatants Minimum total casualties due to enemy action and fratricide Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperability Secure operations Nonexploitability	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) CC&D Lack of standardized datalink Affordability Vulnerability	Fusion Database management Radar imaging/processing Laser development/processing IR focal plane array Advanced IR sensors ESM Secure datalinks ATR development Target phenomenology and modeling Low-cost north reference unit/inclinometer
Operational Capability Element: Surface to Air			
Robust, high-confidence ID capability at range commensurate with range and lethality of weapons Maximum military effectiveness of combatants Minimum total casualties due to enemy action and fratricide Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperability Secure operations Nonexploitability	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) Lack of standardized datalink Affordability Vulnerability	Fusion Database management Radar imaging/processing Laser development/processing ESM Secure datalinks Target phenomenology and modeling
Operational Capability Element: Air to Air			
Robust, high-confidence ID capability at range commensurate with range and lethality of weapons Maximum military effectiveness of combatants Minimum total casualties due to enemy action and fratricide Automated position reporting and correlation for battlespace (i.e., datalink capability) Interoperability Secure operations Nonexploitability	Foe identification Friend identification Neutral identification Interoperability	Technology limitations (range, ID, accuracy, aspect dependency, timeliness of reporting) Lack of standardized datalink Affordability Vulnerability	Fusion Database management Radar imaging/processing Laser development/processing ESM Secure datalinks Target phenomenology and modeling

CID can be highly useful only when it is fully integrated with both C^3 and weapon systems. It often develops time-urgency far exceeding that for most other C^4I functions. In addition, CID requirements need to be refined through simulation and military exercises. If not defined within that sort of environment, past history suggest that some requirements will be so stringent as to discourage serious development, while others may not be sufficient to satisfy the needs.

CID requires effective and timely synchronization of communications systems with data from real-time surveillance, target tracking, and intelligence systems. The CID output must be coupled with the weapon systems in real time to maximize their effectiveness against enemies. In the past, inability to take advantage of all available information has made CID systems add-ons rather than integrated features of all tactical systems.

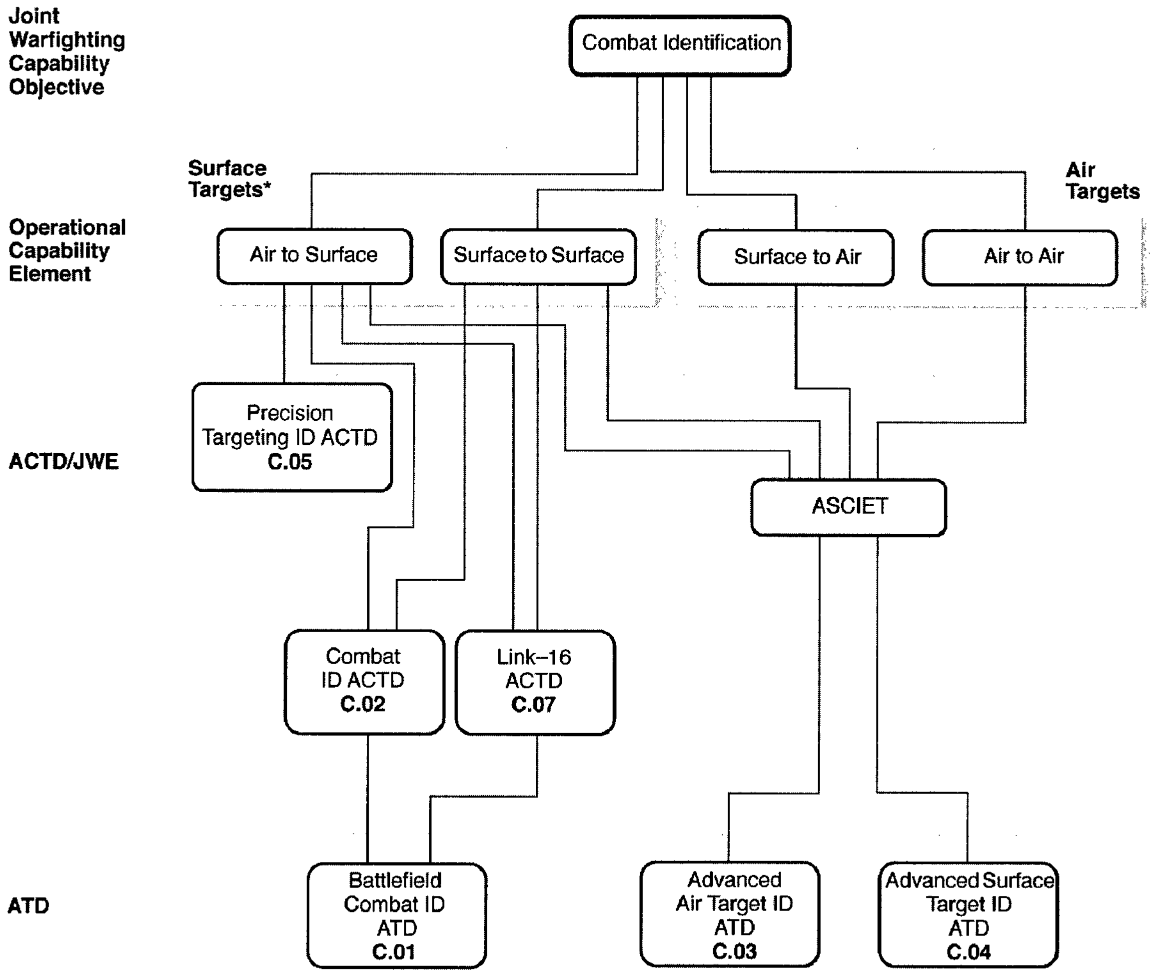
CID capabilities are also vulnerable to enemy exploitation or countermeasures. Vulnerability analyses and evaluations must accompany system design and test programs.

E. TECHNOLOGY PLAN

The roadmap for developing and demonstrating these technologies has two main elements: surface target identification and air target identification. Each element addresses both the affordability and signature exploitability barriers. An overview of the relationship of the CID operational capability elements, functional capabilities, demonstrations, and supporting technologies is shown in Figure VI–2. Evaluations and demonstrations of technologies can be provided in exercises conducted by, for example, the All-Service Combat Identification Evaluation Team (ASCIET). ASCIET can evaluate current CID concepts and TTP while simultaneously providing a venue for emerging technology development.

The primary DTOs and their corresponding demonstrations that address the CID operational capabilities are shown in Tables VI–3 and VI–4. The Military Operations in Urban Terrain (MOUT) ACTD (E.02), which will explore small-unit operations in an urban terrain, will address some CID issues; and the Future Scout and Cavalry System DTO (GV.01.06), which will demonstrate the operational potential of a lightweight scout vehicle integrating scout-specific technologies with complementary advanced vehicle technologies, will include some CID aspects. The DTO roadmap is shown in Figure VI–3. Below is a list of the primary DTO efforts:

- *C.01, Battlefield Combat Identification (BCID) ATD*, will demonstrate technologies that address the ground combat ID problem and will enhance the warfighter's combat effectiveness while reducing the potential for fratricide incidents.
- *C.02, Combat Identification (CID) ACTD*, will demonstrate a joint air-to-surface and surface-to-surface combat ID capability, focusing on close air support (fixed-wing aircraft), close support (helicopter/rotary wing), and ground-to-ground mission areas. This DTO will enhance combat effectiveness and reduce fratricide.
- *C.03, Advanced Air Target Identification ATD*, will develop and demonstrate advanced, long-range, combat ID capabilities for air target ID for use on current and next-generation aircraft. These capabilities will be jam resistant, with an ID confidence probability of 99 percent.



Supporting DTOs

JWSTP

B.05	Target Acquisition ATD
B.06	Air/Land Enhanced Reconnaissance and Targeting ATD
E.02	Military Operations in Urban Terrain ACTD

DTAP

GV.01.06	Future Scout and Cavalry System
SE.03.01	Advanced Radar Processing From Airborne Platforms
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing
SE.09.02	Multiwavelength, Multifunction Laser
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	Automatic Target Recognition for Reconnaissance and Surveillance
SE.33.01	Advanced Focal Plane Array Technology

* Surface = Ground + Maritime

Figure VI–2. Technology to Capability—Combat Identification

Table VI–3. Defense Technology Objectives—Combat Identification

DTO No.	Title
C.01	Battlefield Combat Identification ATD
C.02	Combat Identification ACTD
C.03	Advanced Air Target Identification ATD
C.04	Advanced Surface Target Identification ATD
C.05	Precision Targeting Identification ACTD
C.07	Link–16 ACTD
B.05	Target Acquisition ATD
B.06	Air/Land Enhanced Reconnaissance and Targeting ATD
E.02	Military Operations in Urban Terrain ACTD
GV.01.06	Future Scout and Cavalry System
SE.03.01	Advanced Radar Processing From Airborne Platforms
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing
SE.09.02	Multiwavelength, Multifunction Laser
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.20.01	Automatic Target Recognition for Reconnaissance and Surveillance
SE.33.01	Advanced Focal Plane Array Technology

Table VI–4. Demonstration Support—Combat Identification

	Operational Capability Elements					Type of Demonstration		
Demonstration	Air to Surface	Surface to Surface	Surface to Air	Air to Air	Service/ Agency	DTO	ACTD	ATD
Battlefield Combat Identification ATD	●	●			Army	C.01		X
Combat Identification ACTD	●	●			Joint	C.02	X	
Advanced Air Target Identification ATD			○	●	Air Force	C.03		X
Advanced Surface Target Identification ATD	●	○	○	○	Air Force, Navy	C.04		X
Precision Targeting Identification ACTD	●		○	○	Navy	C.05	X	
Link–16 ACTD	●	●			Joint	C.07	X	
Target Acquisition ATD		●			Army	B.05		X
Air/Land Enhanced Reconnaissance and Targeting ATD	●			○	Army	B.06		X
Military Operations in Urban Terrain ACTD		●			Joint	E.02	X	
Future Scout and Cavalry System		●			Army	GV.01.06		
Advanced Radar Processing From Airborne Platforms		●			Air Force	SE.03.01		
Multifunction Electro-Optical Sensors and Signal Processing	●	●	●	●	Navy	SE.06.01		
Multiwavelength, Multifunction Laser	●	●			Air Force	SE.09.02		
Affordable ATR via Rapid Design, Evaluation, and Simulation	●	●		●	Army	SE.19.03		
Automatic Target Recognition for Reconnaissance and Surveillance	●	●		●	DARPA	SE.20.01		
Advanced Focal Plane Array Technology	●	●	●	●	DARPA	SE.33.01		

● Strong Support ○ Moderate Support

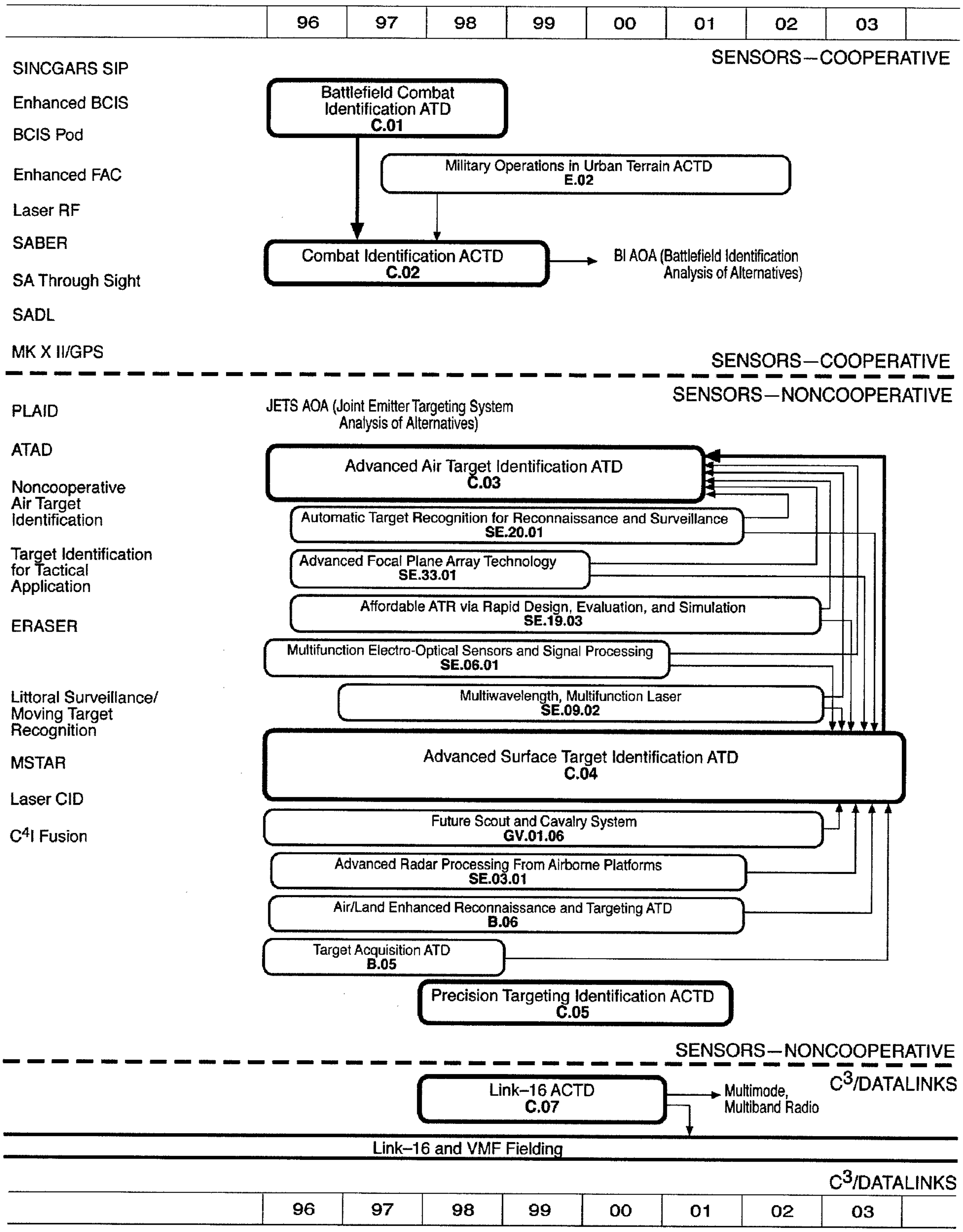


Figure VI–3. Roadmap—Combat Identification

- *C.04, Advanced Surface Target Identification ATD,* will develop and demonstrate advanced, long-range, air-to-surface target ID capabilities for use on current and next-generation aircraft. The system produced by this DTO will be a multifunction device that incorporates at least two different, but complementary techniques, resulting in an ID confidence probability of 98 percent.
- *C.05, Precision Targeting Identification (PTI) ACTD,* will demonstrate the standoff aspect invariant classification of aircraft and surface targets with a low probability of intercept. This DTO will attempt to improve capabilities in three warfare mission-critical areas: positive ID of noncooperative air targets, over-the-horizon targeting, and battle damage assessment.
- *C.07, Link–16 ACTD,* will provide interoperability between the Link–16 (used in air and maritime operations) and variable message format (VMF) (used in ground operations) networks. This DTO will attempt to reduce or eliminate the occurrence of delayed, incorrect, or incomplete delivery of critical battlespace information caused by current translators/gateways currently used for communicating between Link–16 and VMF systems.

Surface Target Identification. This (ground) element first addresses an integrated air-to-surface (ground, CAS) and surface-to-surface CID capability through the Battlefield Combat Identification (BCID) ATD (C.01), the Combat Identification ACTD (C.02), and the associated EW/sensor fusion/integrated situation assessment technology demonstrations. These demonstrations combine primarily friend identification with improved battlefield situational awareness resulting from the Army's Force XXI initiative. The North Finding Module demonstration addresses a key technology needed for affordable correlation of identification labels within the weapon sight on ground platforms.

The next several steps focus on foe identification using noncooperative techniques. A number of ATDs are critical to this effort, including the Target Acquisition ATD (B.05), Air/Land Enhanced Reconnaissance and Targeting (ALERT) ATD (B.06), and Advanced Surface Target Identification ATD (C.04). Furthermore, the DARPA/Air Force Moving and Stationary Target Acquisition and Recognition (MSTAR) program and the Air Force System-oriented High-range resolution Automatic Recognition Program (SHARP) support the Advanced Air Target Identification ATD (C.03). Additionally, maritime targets are being addressed as part of the Advanced Surface Target Identification ATD (C.04) and the Precision Targeting Identification ACTD (C.05). Improving the ease of integration will allow for the CID solutions that are evolving or extant to be hosted within the architecture with a minimal expenditure of time or money. This element addresses the integration of multiple functions within a CID suite to reduce costs and improvements in the case of physical and functional integration onto combat platforms to achieve more rapidly deployable and affordable CID solutions.

Air Target Identification. The air target identification element represents a more information-rich approach. This element includes both fusion and noncooperative target identification techniques. The Advanced Air Target Identification ATD (C.03), Advanced Surface Target Identification ATD (C.04), and Air Target Algorithm Development Program (part of C.01) address the signal exploitation issues associated with the noncooperative air target identification challenge. These efforts are multidimensional and proceed in parallel. They each include their own data collection

efforts. These signature exploitability efforts are crucial to advancing the capability in noncooperative sensing to support all target identification. It is the intent of this path in the roadmap to have a wide variety of experiments to examine the issues of signature presence, discrimination, and reliability over a broad range of engagement scenarios and battlespace environmental conditions. Each of the integrated CID suite approaches would be used to demonstrate improved operations (enhanced effectiveness and reduced total casualties) in field exercises with both joint and combined forces.

Datalinks. Additionally, a new effort is underway to link the air/maritime environments to the ground environment via the Link–16 ACTD (C.07). This ACTD provides interoperability between the Link–16 and VMF network in support of air-ground and maritime-ground attack missions. Separate datalink message formats and communications media have resulted in untimely, incorrect, or incomplete delivery of crucial battlefield information due to the use of translators/gateways to make these systems "communicate" with one another. Currently, it is difficult to establish seamless information flow among diverse datalink units. A major goal of this ACTD is to start standardizing C^4I messaging and data elements used to provide a seamless, flexible datalink environment. The objective is to demonstrate a joint, integrated capability to pass tactical information seamlessly among Link–16 and VMF networks. This ACTD will be demonstrated by the various U.S. services and potentially some of our NATO allies.

All CID techniques have a limited period of operational effectiveness before they are degraded or compromised by enemy countermeasures. It is therefore necessary to have an ongoing process to overcome these vulnerabilities by developing new technologies for CID, demonstrating new capabilities in appropriate operational environments, and deploying new or upgraded CID appliquès to maintain a superior operational CID capability.

Identification issues associated with weapons of mass destruction (WMD) are addressed in Chapter XII, Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction.

F. SUMMARY

Providing an accurate CID capability when and where it is needed requires an integrated architecture that includes noncooperative/cooperative identification sensor systems, C^3 systems, and doctrine/TTP. Improvements in joint warfighting operational capabilities will be demonstrated using suites of the materiel capabilities on various platforms in joint operational environments.

A significant initial improvement is expected for ground target identification with the inception of new cooperative identification techniques combined with C^3/digital datalinks and radios. This will later be augmented with a foe and neutral identification capability for selected weapon systems.

Air and maritime target identification improvements will be achieved by increasing the robustness of overall CID capabilities by improving noncooperative techniques, providing more capable datalinks, adding data fusion/correlation capabilities, and expanding the number of platforms equipped. The improvements in demonstrated warfighting capabilities over time are shown in Figure VI–4.

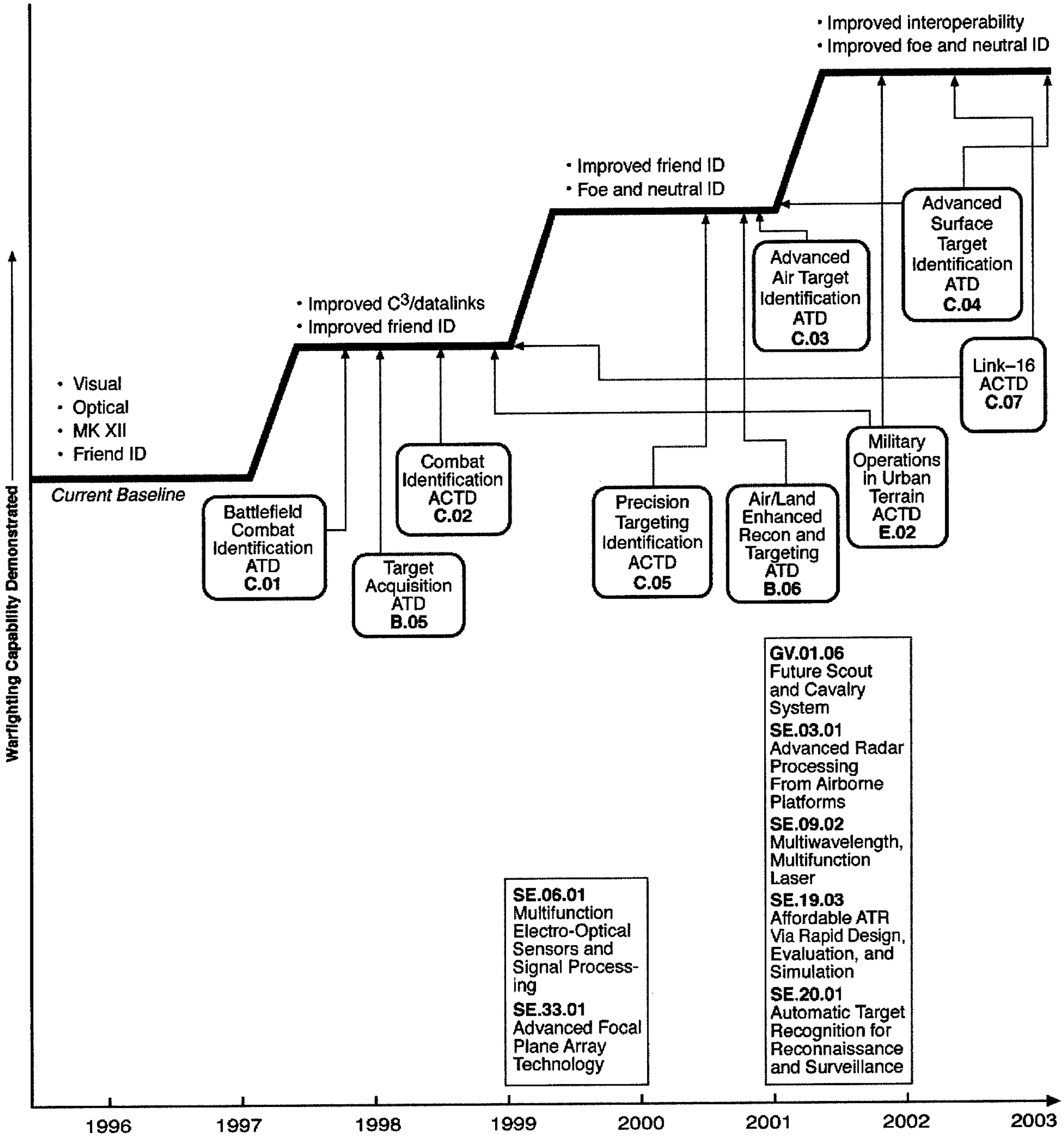


Figure VI-4. DTO Progress—Combat Identification

CHAPTER VII

JOINT THEATER MISSILE DEFENSE

CHAPTER VII
JOINT THEATER MISSILE DEFENSE

A. DEFINITION

Joint Theater Missile Defense (JTMD) is the capability to use the assets of multiple services and agencies to detect, track, acquire, and destroy enemy theater ballistic missiles and cruise missiles. It includes the seamless flow of information on missile launches by specialized surveillance capabilities, through tracking by sensors from multiple services and agencies, to missile negation or destruction.

The vision for a future JTMD architecture is shown conceptually in Figure VII–1. It depicts a representative theater-wide set of surveillance systems, multiple layers of defensive weapon systems, and a highly responsive C^3I network to integrate the surveillance and weapon capabilities. The internetted set of surveillance systems depicted includes airborne, shipborne, and land-based radars plus space surveillance systems to detect launches of theater ballistic and cruise missiles and track them until they are successfully intercepted.

In this future JTMD architecture, the first of the defensive layers is *boost-phase intercept* of ascending ballistic missiles by airborne or space-based high-power laser weapon systems, or both,

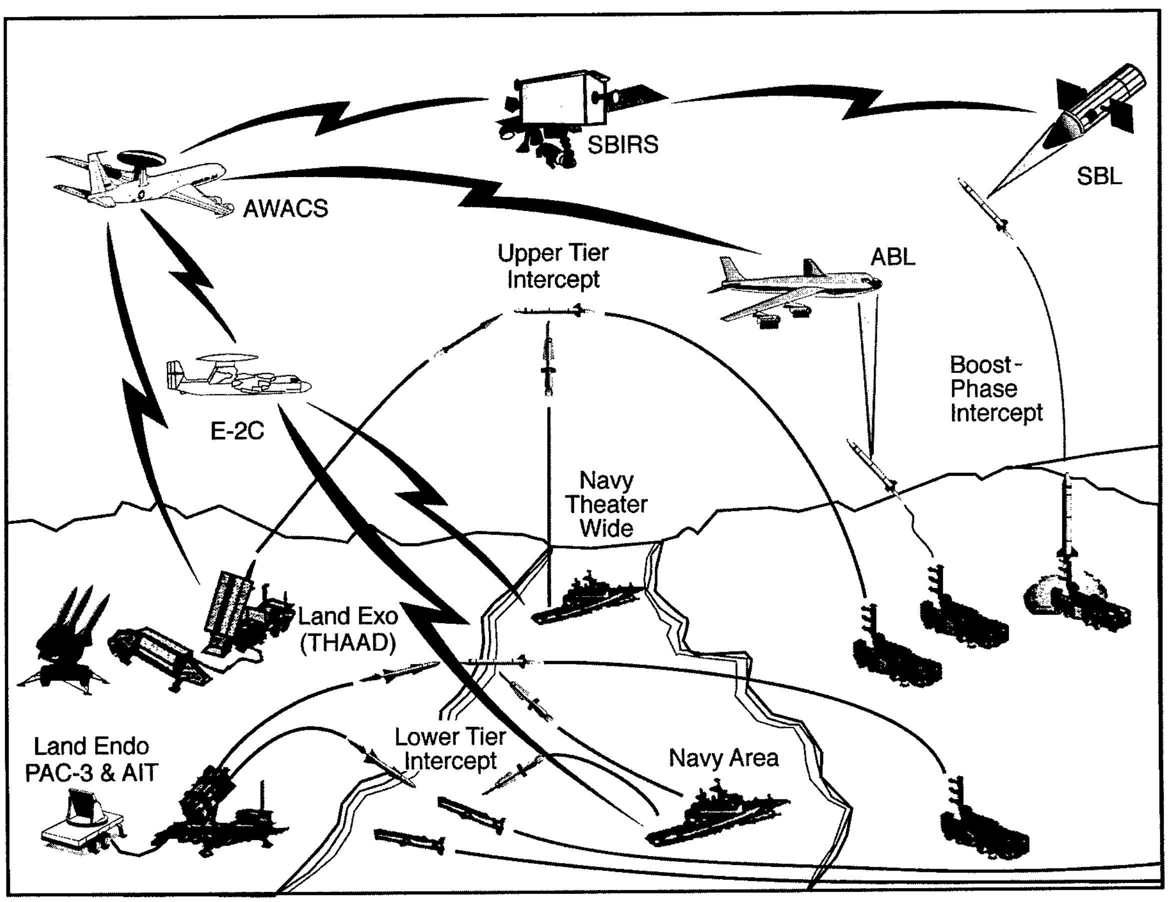


Figure VII–1. Concept—Joint Theater Missile Defense

as shown conceptually in Figure VII–1. This boost-phase intercept layer offers a special contribution to deterring or defeating attacks by missiles armed with weapons of mass destruction (WMD) (chemical, biological, or nuclear warheads), because lethal warhead materials could fall on the attacker's own territory. For the next defensive layer, or *upper tier,* long-range interceptor missiles from land or shipboard launchers are depicted intercepting at high altitude the missiles that avoided boost-phase intercept. The final defensive layer, or *lower tier,* includes shorter range defensive missiles from land- or sea-based launchers to provide a final round of lower altitude terminal intercepts above the defended area. Similarly, cruise missiles detected by the surveillance sensors could be intercepted first by longer range sea- and land-based surface-to-air and air-to-air missiles and then by the shorter range terminal defense missiles.

JTMD capabilities are critical elements of the new operational concept of *full-dimensional protection* envisioned in *Joint Vision 2010.* The Theater Missile Defense Mission Need Statement defines the mission of JTMD as protecting U.S. forces, U.S. allies, and other important countries, including areas of vital interest to the U.S., from theater missile attacks. The JTMD mission includes the protection of population centers, fixed civilian and military assets, and mobile military units.

B. OPERATIONAL CAPABILITY ELEMENTS

The four operational capability elements, or pillars, of JTMD are *attack operations, active defense, passive defense,* and *command, control, communications,* and *intelligence (C^3I)*. These are shown in Table VII–1.

This section focuses on the *active defense* pillar and those aspects of the *C^3I* pillar that are unique to the JTMD mission. Capabilities for the *attack operations* pillar such as quick-response, precision strikes against mobile theater missile launchers are addressed in Chapter V, Precision Force. In addition, *attack operations* against WMD capabilities—including prompt attacks against WMD-armed theater missiles on the battlefield and counterforce attacks against hardened WMD storage and production facilities—are addressed in Chapter XII, Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction. Similarly, responsive, theater-wide command, control, communications, computers, and intelligence (C^4I) systems and enhanced theater intelligence, surveillance, and reconnaissance (ISR) capabilities that support all theater operations (including JTMD) are addressed in Chapter IV, Information Superiority. Finally, *passive defense* capabilities—including rapidly assessing and disseminating chemical and biological (CB) threat information and providing effective protection against CB attack for personnel and platforms—are described in Chapter XII, Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction.

**Table VII–1. Functional Capabilities Needed—
Joint Theater Missile Defense**

Functional Capabilities	Operational Capability Elements: C^3I	Active Defense	Passive Defense	Attack Operations
Acquisition Sensor				
1. Detection	○	●	●	●
2. Tracking		●	●	●
3. Discrimination		●	○	○
4. Communications	●	●	●	●
Target Intercept				
5. Lethality—Interceptor		●		
6. Footprint—Interceptor		●		
7. Divert—Interceptor		●		
8. Acquisition		●		
9. Tracking		●		
10. Discrimination		●		
11. Communications	●	●	○	○
12. Boost Phase Intercept—Laser	○	●		○
C^3I				
13. Datalinks	●	●	●	●
14. Waveform	●	●	○	●
15. Data Processing	●	●	●	●
16. Data Fusion	●	●	●	●

● Strong Support ○ Moderate Support

C. FUNCTIONAL CAPABILITIES

The functional capabilities needed to support the four operational capability elements or pillars of JTMD are listed in Table VII–1. The detailed functional capabilities are grouped into those supporting the three functional areas of *acquisition sensor, target intercept,* and C^3I.

In the *acquisition sensor* area, the four functional capabilities are detection, tracking, discrimination, and communications. Rapidly detecting theater missile launches and establishing current and accurate tracks for those missiles are essential for cueing the active defense against the attacking missiles. In addition, the detection, tracking, and communications functional capabilities strongly support passive defense by providing attack warning and impact point predictions to threatened areas. Those three functional capabilities also strongly support attack operations by accurately identifying missile launch locations so that the launchers can be promptly attacked. The discrimination functional capability to distinguish a ballistic missile warhead from accompanying missile

components or fragments and decoys is essential for cueing the active defense to attack the right target. In addition, the attack characterization information about the missile type and potentially the type of warhead from discrimination sensors moderately supports both the attack operations and passive defense operational capabilities, as shown in Table VII–1.

In the *target intercept* area, the first three functional capabilities—lethality, footprint, and divert—specifically refer to capabilities of interceptor missiles (often called *kinetic energy* interceptors in contrast to *directed-energy* or laser intercept). The first, lethality, is the capability to effectively destroy the warhead payload of an attacking missile when the interceptor impacts the target (for hit-to-kill interceptors) or passes near the target and detonates a fragmenting warhead. The second function, footprint, is the capability of an interceptor missile to intercept targets over the required defended area because of its speed, range, and altitude performance capabilities. The related third function, divert, is the lateral acceleration capability of the interceptor missile to maneuver during the final phase, or *end game*, of the intercept in order to impact the target or pass within the interceptor warhead's lethal envelope of the target.

The next three functional capabilities are the capabilities of the sensors on board the interceptor missile or laser weapon platform to (1) acquire the right target based on cueing and handoff information passed from acquisition sensors through the C^3I system, (2) discriminate between the target warhead and missile fragments or decoys, and (3) maintain tracking of that target until the intercept is completed. The communications functional capability links the interceptor missiles or laser platforms to the acquisition sensor functional capabilities. The final target intercept functional capability is boost-phase intercept with laser weapons, either airborne or space based. As indicated in Table VII–1, because of the onboard acquisition sensor and communications capabilities envisioned for them, the laser weapon platforms would also support the C^3I and attack operations operational capabilities by forwarding missile launch and tracking data that they acquired.

The *C^3I* area includes functional capabilities for high-capacity datalinks to rapidly pass acquisition sensor data; and for specialized waveforms to forward missile tracks among elements of the joint TMD forces. C^3I also includes the functional capabilities of very-high-throughput data processing to capture, analyze, and disseminate the sensor data with minimum delays; and data fusion capability to synergistically combine tracking and discrimination data from multiple sensors of different types.

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

Joint Theater Missile Defense includes a number of surveillance, weapons, and C^3I systems that are currently deployed or under development by the services. The Ballistic Missile Defense Organization (BMDO) is responsible for the family-of-systems approach to ensure integration of these systems into a joint warfighting capability. Current theater C^3I systems are being upgraded for interoperability, and future JTMD systems will be linked by interoperable C^3I networks to provide joint connectivity.

Current JTMD capabilities are limited to terminal point defense missile intercepts at low to medium altitudes; there is no capability for upper tier intercepts at higher altitudes and longer ranges or for boost-phase intercept. However, higher performance missiles and surveillance systems now under development will extend intercept capabilities to the higher altitudes and longer ranges

required for theater-wide upper tier missile defense. In addition, technology development and demonstration efforts are underway to establish the feasibility of laser weapons for boost-phase intercept, as will be described in Section E.

The current capability for low-altitude, terminal point defense missile intercepts is based on the PATRIOT and HAWK interceptor missile and radar systems. PATRIOT upgrades, including software enhancements and improved fuzing, have increased engagement capability beyond the level available during Operation Desert Storm. The fielded PATRIOT system allows for rapid, accurate fire unit emplacement, remote launcher placement up to 12 km from the radar, and radar enhancements to improve theater ballistic missile (TBM) detection and increase system survivability. Upgrades to the lower altitude, shorter range HAWK system will yield a near-term defense capability for expeditionary forces through modifications to allow detection, tracking, and engagement of short-range TBMs.

To improve these lower tier defense capabilities, upgrades to both the Army PATRIOT and Navy missile systems are under development. The PATRIOT Advanced Capability 3 (PAC–3) version now under development will enhance PATRIOT system engagement performance by adding a new hit-to-kill missile interceptor with a millimeter-wave seeker and side-firing, divert propulsion thrusters for enhanced maneuverability during the final phase of intercepting a target. In addition, under the Navy Area Defense program, an upgraded version of the Navy Standard Missile 2 (SM–2 Block IV A) is under development to provide a sea-based, lower tier intercept capability. These upgraded PAC–3 and SM–2 Block IV A missiles will also provide improved intercept performance against cruise missiles. In addition, project definition and concept validation is underway for the Medium Extended Air Defense System (MEADS), a highly mobile system to be deployed with maneuver forces to provide coverage against short-range TBMs, cruise missiles, and other aerodynamic threats.

However, these lower tier systems with moderate velocity missiles have only limited capability against longer range TBM threats with higher reentry velocities, particularly if the attacking missiles are fitted with WMD warheads. Chemical or biological warheads intercepted at low altitude could still disperse hazardous materials over defended areas, particularly if the warheads contained submunitions.

Therefore, upper tier TMD systems with high-performance interceptor missiles capable of defending larger areas and intercepting targets, including WMD warheads at higher altitudes, are under development for both land and sea basing. The Army Theater High-Altitude Area Defense System (THAAD) includes a new interceptor missile and a ground-based phased-array acquisition and tracking radar. The Navy Theater Wide system includes a high-performance interceptor missile and upgrades to the AEGIS shipboard phased-array radar software.

The characteristics of the land attack cruise missile threat present special challenges for the JTMD mission. Cruise missiles can fly at low altitudes to avoid detection, can maneuver unpredictably to evade intercept, and can be launched from both aircraft and mobile surface carriers, thus reducing the likelihood of prelaunch suppression. Furthermore, advanced cruise missile designs can have very low radar and infrared signatures that make the missiles very difficult to detect against low-altitude background clutter. Therefore, current surveillance systems and interceptor missiles have only limited capabilities to detect, track, and intercept cruise missiles.

In response to these limitations of current capabilities against cruise missiles, during FY96 the Cruise Missile Defense Phase I ACTD demonstrated the feasibility of the air-directed surface-to-air missile (ADSAM) concept for over-the-horizon engagement of cruise missiles. Under this ACTD, radars on a mountaintop site simulating airborne radars were used to detect and track missiles that would have been over the horizon for ground- or sea-based radars. Engagement data were transmitted to interceptor missiles via the Navy's Cooperative Engagement Capability (CEC) links, and successful live-fire intercepts with SM–2 missiles and simulated intercepts with PATRIOT PAC–3 seekers were demonstrated. This ACTD was a significant step toward demonstrating the feasibility of concepts for the cruise missile defense component of JTMD. In a follow-on effort to the CMD Phase I ACTD, the Navy is conducting an overland CMD S&T program that focuses and aligns technology and engineering efforts associated with the E–2C surveillance aircraft, SM–2 missile, and a seamless weapon control architecture.

For space surveillance capabilities beyond those available from the current Defense Support Program (DSP) infrared missile launch detection satellites, development of the Space-Based Infrared Systems (SBIRS), including both low- and high-altitude surveillance satellite constellations, is programmed.

Key limitations of current technologies that now preclude development of the functional capabilities needed to fully satisfy the JTMD goals are highlighted in the third column of Table VII–2, Goals, Limitations, and Technologies for JTMD. For example, for the target intercept functional capability, key limitations include discrimination of the actual target in the face of a sophisticated threat including decoys, tracking of maneuvering targets, lack of a current capability for boost-phase intercept, and the inability to defeat early-release submunitions.

Discrimination is a key limitation for defense against TBMs because an approaching group of apparent targets could include multiple missile components or fragments and, potentially, decoys in addition to the actual reentry vehicle containing the warhead. Without effective discrimination sensors to confidently identify the actual warhead, multiple missile or laser shots would be required to destroy all of the potentially threatening objects to ensure a high probability of protecting the defended area. Therefore, effective discrimination technology has very high payoff for JTMD. For endoatmospheric interceptors, a limitation on using onboard sensors for discrimination and target tracking is the limited availability of IR and RF window materials that are transparent at the required wavelengths, have low distortion, and can survive the high temperature and pressure of hypersonic flight within the atmosphere.

Target maneuvering is another key limitation that imposes additional lateral acceleration and divert propulsion requirements on missile interceptor technology. Current TBMs may maneuver unpredictably during reentry because of missile dynamics or reentry vehicle asymmetries, and advanced reentry vehicles could potentially take evasive maneuvers, thus reducing the probability of successful intercept. Therefore, technologies that enhance interceptor maneuverability and improve interceptor probability of kill would allow a reduction in interceptor inventory and could significantly reduce JTMD costs.

Table VII–2. Goals, Limitations, and Technologies—Joint Theater Missile Defense

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Command, Control, Communications, and Intelligence (C^3I)			
Coordinate exchange of information among sensors, radars, launch platforms, interceptors, and command centers.	*Acquisition Sensor* Communications *Target Intercept* Communications *C^3I* Datalinks Waveform Data Processing Data Fusion	Network latency Datalink capacity	Laser communications High-speed optical datalinks Solid-state nonvolatile memory High-capacity computer interface
Operational Capability Element: Active Defense			
Acquire and track target and handover/communication data to command centers, interceptor launch sites, and laser platforms.	*Acquisition Sensor* Detection Tracking Discrimination Communications	Full constellation coverage Radar survivability Target recognition Radar power constraints Lack of airborne TMD disseminator	Advanced lightweight signal processor High-power T/R modules Large-format, high-uniformity, single-band and multiband LWIR focal plane arrays Lightweight antennas Cryogenic power Eyesafe laser radar
Negate the threat.	*Target Intercept* Lethality—interceptor Footprint—interceptor Divert—interceptor Acquisition Tracking Discrimination Communications Boost phase intercept—laser	Discrimination of sophisticated threat Tracking of maneuvering vehicles No capability for boost-phase intercept Inability to defeat early-release submunitions Design for divert jet interactions in the atmosphere	Solid-propellant divert Onboard sensor signal processor and algorithms Lightweight laser radar High-sensitivity multispectral IR sensor Fast framing seeker Sensor windows (IR and RF) for hypersonic atmospheric interceptors Sensor data fusion Target discrimination algorithms Lightweight chemical laser Adaptive optics and beam control Atmospheric compensation and tracking High-stiffness, lightweight structures
Receive, process, and transfer data.	*C^3I* Datalinks Waveform Data processing Data fusion	Network latency Datalink capacity Data fusion delays	Omni-EHF antenna Advanced fusion algorithm

Table VII–2. Goals, Limitations, and Technologies—Joint Theater Missile Defense (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Passive Defense			
Early, long-range, and accurate threat acquisition, tracking, and data distribution.	*Acquisition Sensor* Detection Tracking Discrimination Communications *C^3I* Datalinks Waveform Data Processing Data Fusion	Delayed detection of launch Slow impact point projection Detection of early-release submunitions	Laser communications Satellite electric propulsion High-efficiency photovoltaics LWIR GaAs sensor Active pixel visible sensor
Operational Capability Element: Attack Operations			
Coordinate cooperative acquisition, tracking, decision making, and kill assessment.	*Acquisition Sensor* Detection Tracking Discrimination Communications *C^3I* Datalinks Waveform Data Processing Data Fusion	Noninteroperable communications links Inaccurate kill assessment of CB threats	High-speed datalinks Target discrimination algorithms CDMA spread-spectrum communications modem

Two other significant barriers for JTMD are sensor/data fusion and target signature data. Sensor fusion is a challenging technical barrier for TMD because fusion must take place in near-real time in order to be useful for guiding intercepts. Sensor data fusion is a technique in which multiple sensors provide individual data sets on targets and backgrounds, which are then processed into a single merged set of data. The fused data present a much more accurate picture of the battlespace to the field commanders than the sum of the individual data sets. The data fusion process occurs in one of three ways: (1) the fusion of data from several sensors on the same platform (e.g., a thermal imaging sensor and laser radar onboard an interceptor or a space surveillance satellite); (2) the transfer or handover of data from one sensor platform to another (e.g., target object map data handover from one surveillance sensor to an interceptor); or (3) the merging of track files recorded and processed from two or more geographically separated sensors (e.g., ground radar and space surveillance sensor data track files).

Availability of accurate target signature data is also a key barrier because successful TMD detections and intercepts, particularly hit-to-kill intercepts, require accurate and reliable target signatures. Threat signatures drive the designs of the detection and tracking radars and optical sensors and the seeker hardware selections. They also establish requirements for the supporting detection, discrimination, aimpoint selection, and kill assessment algorithms. The primary limitation on obtaining accurate signatures is generally the lack of access to the actual missile threats operating in their deployed environment. To compensate for this, BMDO supports a robust threat and

signatures flight and phenomenology program where both simulated threats and acquired threats are flown and measured.

Some potential barriers to operating in disturbed environments that are not unique to the JTMD mission—such as achieving mission goals in the presence of jamming, weather, and solar and nuclear disturbances—are addressed by DTOs in the Sensors, Electronics, and Battlespace Environment chapter of the DTAP. Some of these efforts are referenced in the next section.

E. TECHNOLOGY PLAN

Some of the key technologies needed to breach the limitations to achieving the JTMD functional capabilities and to enable the JTMD operational capability elements are shown in Figure VII–2. Most of these key technologies are being addressed by the technology development and demonstration efforts encompassed by the six DTOs listed in Table VII–3 that are cited in this chapter as most directly supporting JTMD. In addition, as discussed in Section B above, related technology efforts described in other sections of this JWSTP also support JTMD operational capabilities: technology demonstrations under Precision Force (Chapter V) that support the JTMD attack operations capability, efforts under Information Superiority (Chapter IV) that support C^3I capabilities applicable to JTMD, and technologies under Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction (Chapter XII) that support the JTMD passive defense operational capability.

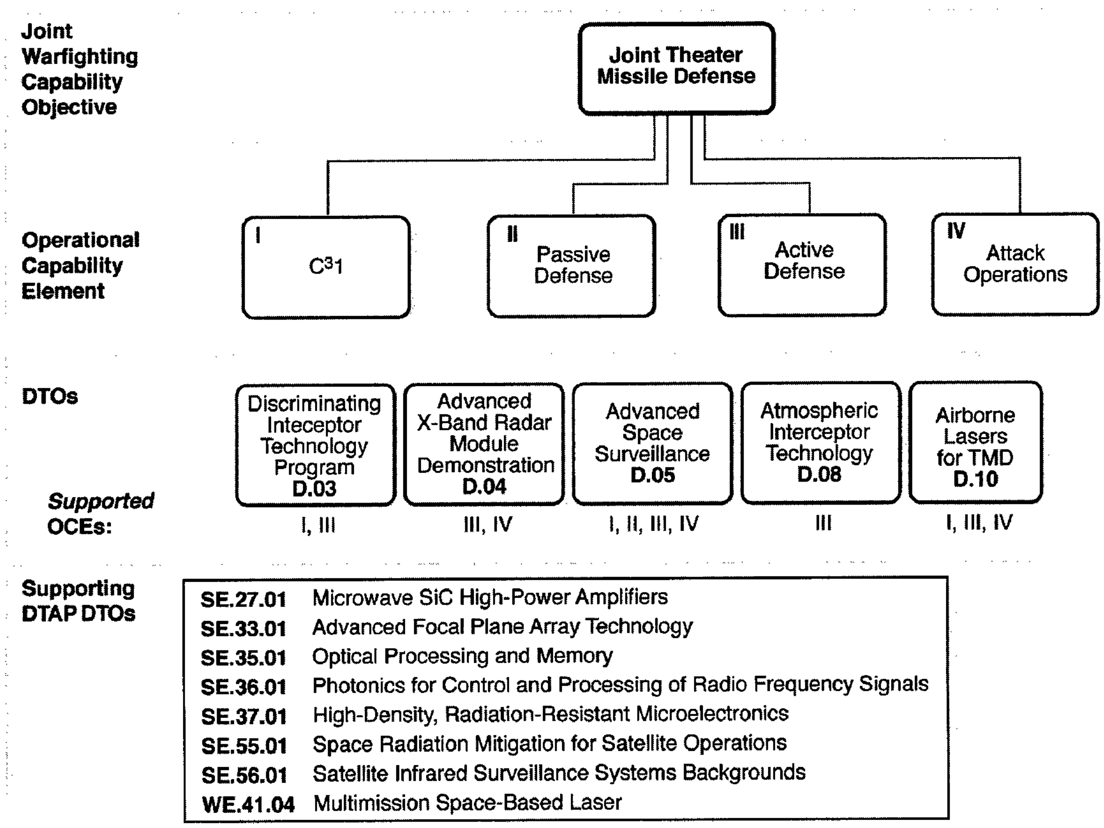


Figure VII–2. Technology to Capability—Joint Theater Missile Defense

**Table VII–3. Defense Technology Objectives—
Joint Theater Missile Defense**

DTO No.	Title
D.03	Discriminating Interceptor Technology Program
D.04	Advanced X-Band Radar Module Demonstration
D.05	Advanced Space Surveillance
D.08	Atmospheric Interceptor Technology
D.10	Airborne Lasers for Theater Missile Defense
SE.27.01	Microwave SiC High-Power Amplifiers
SE.33.01	Advanced Focal Plane Array Technology
SE.35.01	Optical Processing and Memory
SE.36.01	Photonics for Control and Processing of Radio Frequency Signals
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.55.01	Space Radiation Mitigation for Satellite Operations
SE.56.01	Satellite Infrared Surveillance Systems Backgrounds
WE.41.04	Multimission Space-Based Laser

Technology development and demonstration efforts directly supporting JTMD are focused on the following four areas. First, enhance ground and airborne radar and space and airborne optical sensor capabilities to improve missile launch detection, tracking, and discrimination. Second, improve interceptor missile performance, including onboard discrimination and divert maneuvering capabilities for both exo- and endo-atmospheric interceptors. Third, demonstrate the feasibility of boost-phase intercept with airborne and space-based laser technologies. Fourth, increase the capabilities of theater C^3I systems to rapidly process and transfer the massive amounts of sensor and tracking data required to support defensive intercepts.

In the area of enhanced surveillance, tracking, and discrimination sensor technologies, the three key DTOs are D.03, D.04, and D.05. Technology efforts under D.03, Discriminating Interceptor Technology Program, will use in-flight experiments to demonstrate the ability to observe the target, decoys, and debris and perform real-time discrimination between them using a fused LADAR/IR seeker. D.04, Advanced X-Band Radar Module Demonstration, will develop new technology transmit/receive modules that could significantly increase the tracking and discrimination capabilities of the THAAD radar. The Advanced Space Surveillance DTO, D.05, includes technologies for advanced satellite sensors and subsystems that could be inserted into new and upgraded space surveillance systems, including the SBIRS.

Additional details on the six DTOs that most directly contribute to achieving JTMD warfighting capabilities are given below. These DTOs directly support the four JTMD operational capability elements of attack operations, active defense, passive defense, and C^3I, as presented in Table VII–4. The DTOs are structured to demonstrate incrementally increasing capability over time. These technology advances can potentially be inserted into JTMD surveillance, weapons, and C^3I systems at the component and subsystem level to provide warfighting capability that incrementally

Table VII–4. Demonstration Support—Joint Theater Missile Defense

Demonstration	Operational Capability Elements: Attack Operations	Active Defense	Passive Defense	C^3I	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Discriminating Interceptor Technology Program		●		○	BMDO, Army, Air Force, Navy	D.03		
Advanced X-Band Radar Module Demonstration	○	●	○	○	BMDO, Army	D.04		
Advanced Space Surveillance	○	●	○	○	BMDO, Air Force	D.05		
Atmospheric Interceptor Technology		●			BMDO, Army	D.08		
Airborne Lasers for Theater Missile Defense	○	●	○	○	Air Force	D.10		
Microwave SiC High-Power Amplifiers	○	●			Air Force, Navy, DARPA	SE.27.01		
Advanced Focal Plane Array Technology	○		●	●	Army, Navy, Air Force, DARPA	SE.33.01		
Optical Processing and Memory	○	○	○	●	Air Force	SE.35.01		
Photonics for Control and Processing of Radio Frequency Signals	○	○	○	●	Air Force, Navy	SE.36.01		
High-Density, Radiation-Resistant Microelectronics	○	○	●	●	Air Force, DSWA	SE.37.01		
Space Radiation Mitigation for Satellite Operations	○	○	●	●	Air Force	SE.55.01		
Satellite Infrared Surveillance Systems Backgrounds	●	○	●	○	Air Force, BMDO	SE.56.01		
Multimission Space-Based Laser	○	●	○	○	BMDO	WE.41.04		

● Strong Support ○ Moderate Support

increases over time. Full-page descriptions of the DTO technical content, milestone schedules, funding, and performing organizations are presented in the accompanying DTO volume. DTO D.02, Integrated Sensor/Data Fusion Demonstration (which appeared in the January 1997 edition of the JWSTP), has been incorporated into D.03, Discriminating Interceptor Technology Program.

- *D.03, Discriminating Interceptor Technology Program,* develops and demonstrates, through in-flight experiments, the key technologies required to provide an exoatmospheric interceptor with the discrimination capabilities required to distinguish a reentry vehicle from accompanying missile fragments and decoys.

- *D.04, Advanced X-Band Radar Module Demonstration,* will greatly increase power, efficiency, and lifetime of solid-state transmit/receive (T/R) modules by exploiting advanced gallium arsenide and wide-bandgap semiconductor device technologies and advanced monolithic microwave integrated circuit (MMIC) packaging technologies. This advanced T/R module design could directly replace the current module design in the National Missile Defense (NMD) phased-array ground-based radar (GBR) and provide a follow-on improvement in the THAAD GBR.

- *D.05, Advanced Space Surveillance,* includes development of innovative technologies for key space surveillance subsystems. These technologies include a unique multimode sensor, data fusion algorithms, hardware for onboard data processing, a laser satellite-to-satellite communication system, improved solar arrays, and increased-efficiency, long-life Hall Effect thrusters.
- *D.08, Atmospheric Interceptor Technology,* includes development and demonstration at the prototype component level of several key technologies that would be required for a hypersonic hit-to-kill missile for intercepts within the lower atmosphere. The AIT is currently testing technologies that will enable lightweight vehicles to intercept at high velocity (4 km/s), with aimpoint accuracy.
- *D.10, Airborne Lasers for Theater Missile Defense,* develops and demonstrates technology for the airborne laser (ABL) system acquisition program. Specific demonstrations include active tracking field tests against boosting missiles, and ground testing of integrated atmospheric compensation and tracking.
- *SE.27.01, Microwave SiC High-Power Amplifiers,* provides compact, lightweight, highly efficient microwave solid-state transmitter building blocks for possible use in high-performance radar, communications, and electronic warfare systems. These advanced field effect transistor (FET) and static induction transistor (SIT) amplifiers will satisfy the output power, power density, efficiency, linearity, operating voltage, and temperature requirements necessary to provide size, reliability, and life-cycle cost advantages over competing Si- and GaAs-based solid-state amplifiers and tube-based RF transmitter systems.
- *SE.33.01, Advanced Focal Plane Array (FPA) Technology,* includes both cooled and uncooled FPA technology. The objective is to increase range and target acquisition by improving the noise-equivalent delta temperature (NEDT) of uncooled sensors and by fusing two or more bands of cooled detectors, resulting in higher target discrimination.
- *SE.35.01, Optical Processing and Memory,* will develop new optical concepts to achieve tera-operations-per-second processing in a massively parallel optoelectronic processor that is small in size and low in power consumption.
- *SE.36.01, Photonics for Control and Processing of Radio Frequency Signals,* will develop photonics technology to route, control, and process RF and microwave signals in military applications, including photonic components and systems for control of phase-array antennas and distribution of RF signals.
- *SE.37.01, High-Density, Radiation-Resistant Microelectronics,* addresses the high-performance, extremely dense, radiation-resistant microelectronics that are key to continued U.S. domination of battlefield surveillance, intelligence, and communications, as well as joint theater missile defense. Space applications, which presently dominate requirements for radiation-resistant microelectronics, need to operate reliably after exposure to natural and nuclear radiation. This DTO provides satellites, strategic ballistic missiles, and BMDO interceptors with timely access to state-of-the-art microelectronic technologies that are both affordable and radiation resistant. The technologies developed will provide significant reductions in weight, size, and power while simultaneously increasing performance.

- *SE.55.01, Space Radiation Mitigation for Satellite Operations*, addresses the increasingly critical need for space-based assets to provide uninterrupted support to military operations. Space radiation can cause transients in, or failure of, sensitive electronic components and premature degradation of space power systems and other satellite systems. This DTO will establish the causal relationship between the space radiation environment, satellite anomalies, and satellite system degradation and failure; and develop techniques and instrumentation to mitigate these effects or provide warning of hazardous space environments.
- *SE.56.01, Satellite Infrared Surveillance Systems Backgrounds*, develops and demonstrates integrated background clutter suppression and mitigation technologies needed by space surveillance and threat warning systems to detect and track targets in cluttered optical and infrared backgrounds. Advances in target–background discrimination will be pursued through the development and integration of background clutter suppression tools into hardware simulators to optimize system performance prior to deployment for the full system design trade space and operational conditions. The technologies developed under this DTO will support the design and operation of the Space-Based Infrared System.
- *WE.41.04, Multimission Space-Based Laser*, demonstrates the technologies for high-power space-based laser systems that could be used for TBM boost-phase intercept. This DTO integrates a high-power chemical laser with a beam director and tracking components in a lightweight, flight-representative ground test configuration.

The schedules for key technology efforts supporting these DTOs and the relationships among the technology efforts and DTOs are depicted in Figure VII–3.

In addition to the six DTOs cited above that exclusively or primarily support JTMD, there are other DTOs in the DTAP that are advancing technologies important to future JTMD capabilities. For example, for space-based surveillance systems detecting TBMs against the earth background, the complexity and variability of the background clutter are key limitations for detecting dimmer missile targets. Therefore, the development, validation, and demonstration of advanced background clutter algorithms and prediction codes under the Satellite Infrared Surveillance Systems Backgrounds DTO (SE.56.01) are crucial for future JTMD space surveillance systems. From the same Sensors, Electronics, and Battlespace Environments technology area of the DTAP, the technologies for dual-band, cooled infrared focal plane arrays (FPAs) and highly uniform, uncooled FPAs that are being developed under the Advanced Focal Plane Array Technology DTO (SE.33.01), support and are closely integrated with efforts under the JWSTP DTO D.03.

From the same technology area, radiation-tolerant and hardened microelectronics technologies from the High-Density Radiation-Resistant Microelectronics DTO (SE.37.01) will be needed for some JTMD surveillance systems and interceptor missiles facing natural space radiation and potential nuclear weapon environments. Processing analog signals from FPAs in surveillance sensors or on interceptor missiles to detect dim targets against complex backgrounds or digitizing radar signals to detect cruise missiles in ground clutter requires very-high-resolution, high-speed analog-to-digital converter technology from this technology area. Similarly, the technology efforts under the Microwave SiC High-Power Amplifiers DTO (SE.27.01) complement the advanced transmit/receive module technology efforts under JTMD DTO D.04. The Space Radiation Mitigation for

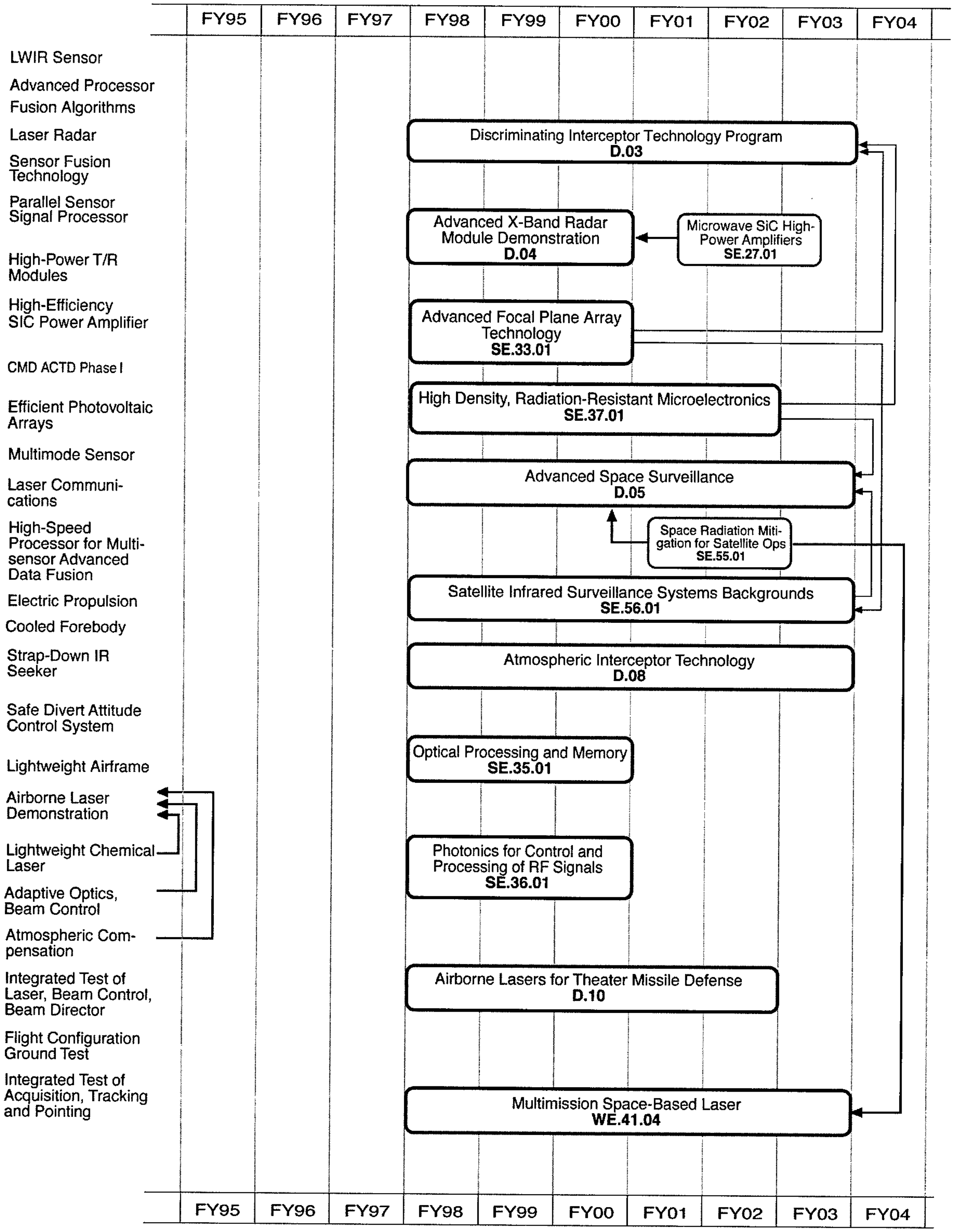


Figure VII–3. Roadmap—Joint Theater Missile Defense

Satellite Operations DTO (SE.55.01) develops techniques to address the adverse effects of space radiation that may impact JTMD DTOs D.05 and WE.41.05. Finally, efforts under the photonics thrust DTOs—Optical Processing and Memory (SE.35.01) and Photonics for Control and Processing of Radio Frequency Signals (SE.36.01)—support key technology needs in laser communications, high-speed optical datalinks, solid-state nonvolatile memory, and high-capacity computer interfaces under the JTMD C^3I Operational Capability Element (Table VII–2).

F. SUMMARY

The incremental advances in demonstrated technology available to support JTMD warfighting capabilities are depicted in Figure VII–4. The dates shown in the figure are the timeframes in which JTMD technologies are projected to have been successfully demonstrated based on ongoing or programmed technology development and demonstration efforts; they are *not* the timeframes in which operational systems incorporating those technologies would be deployed. Once the technology demonstrations are completed, the technologies are expected to be sufficiently mature and the engineering risk sufficiently low that those technologies could be incorporated into the designs for modifications to deployed systems or into new systems. Development, production, and deployment of those operational systems incorporating the advanced technologies would require additional time and funding. For some technologies that could be retrofitted at the component or subsystem level as modification kits into systems already deployed, the development and upgrade period could be relatively short. However, for other technologies that would require major modifications to systems already deployed or in development or that would require development of new systems, the time from a technology demonstration milestone to a deployed operational JTMD capability could be many years.

By FY 2001, enhanced surveillance, acquisition, tracking, and discrimination capabilities against TBMs will be accessible by exploiting the technologies demonstrated under the Advanced X-Band Radar Module Demonstration program. Next, the initial demonstration of boost-phase intercept of a ballistic missile is scheduled for FY2002 under the Air Force's Airborne Laser program using technology developed under the Airborne Lasers for TMD DTO.

Beyond FY2004, robust JTMD capabilities—including advanced space-based surveillance, boost-phase intercept by airborne and space-based lasers, and onboard discrimination for both exo- and endo-atmospheric interceptors—will become attainable from the technology demonstrations under the surveillance, laser, and advanced interceptor DTOs, as shown in Figure VII–4. As depicted conceptually in Figure VII–1 at the beginning of this section, such a robust future JTMD architecture would provide a full theater defense against ballistic and cruise missiles that would include over-the-horizon targeting and tracking of TBM launches, precision targeting of land attack cruise missiles, TBM intercept above the atmosphere by exoatmospheric interceptors with superior discrimination capability, and high endoatmospheric intercept of TBMs.

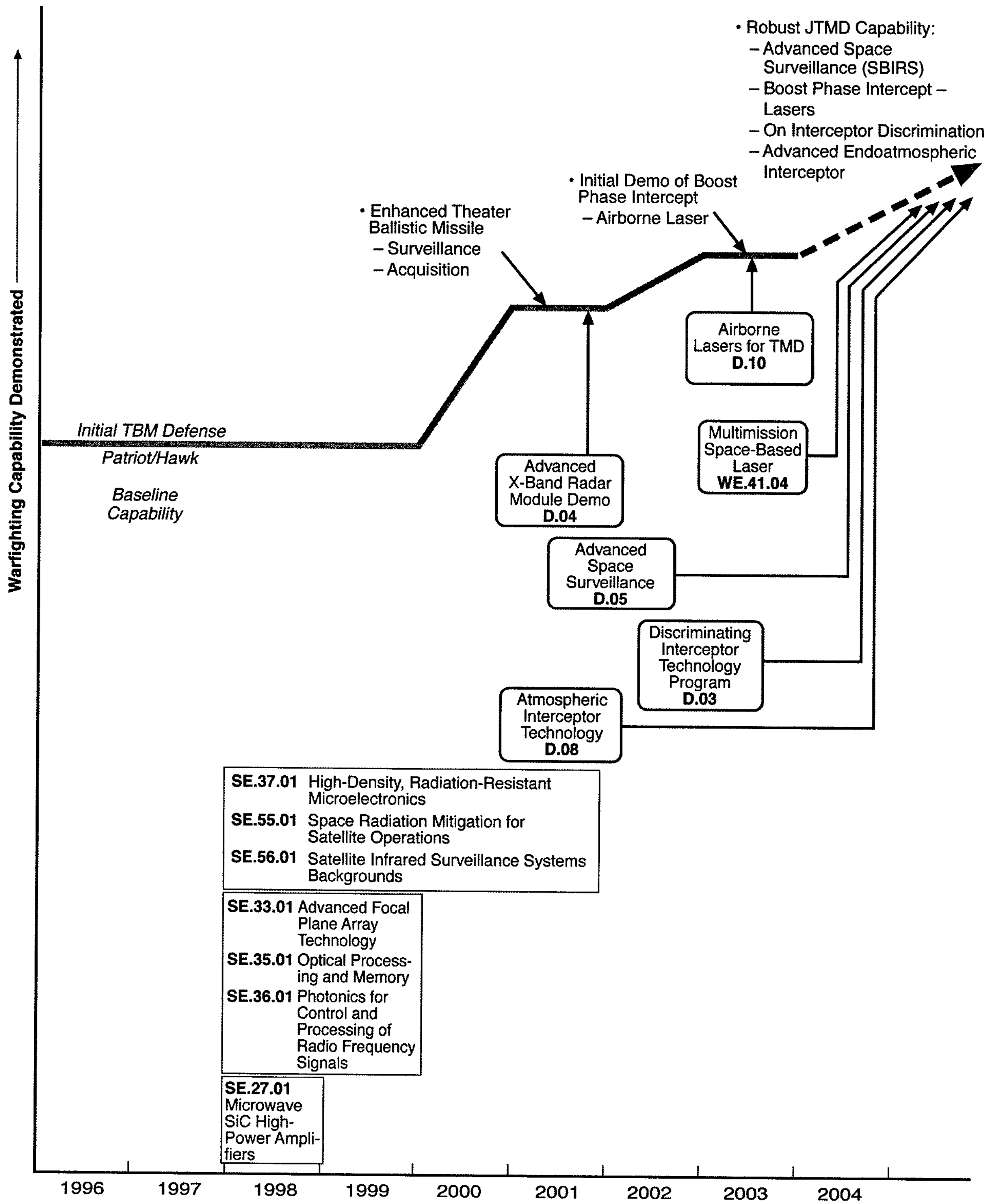


Figure VII–4. Progress—Joint Theater Missile Defense

CHAPTER VIII

MILITARY OPERATIONS IN URBAN TERRAIN (MOUT)

CHAPTER VIII
MILITARY OPERATIONS IN URBAN TERRAIN (MOUT)

A. DEFINITION

Military Operations in Urban Terrain (*MOUT*) is the capability to operate and conduct military operations in built-up areas and to achieve military objectives with minimum casualties and collateral damage. MOUT includes nonlethal weapons, precise weapons, surveillance, and situation awareness via communications effective in urban areas.

MOUT is not so much a unique capability as an environment in which the operational concepts of *Joint Vision 2010*—specifically precision engagement, full-dimensional protection, dominant maneuver, and focused logistics—will be tested under the most demanding conditions. In the near term, the emphasis will be on the exploitation and integration of existing technologies into systems offering improved capability for firepower, force protection, and maneuver in the urban environment. The long-term emphasis—which will form the basis for a true transformation of the traditional functions of strike, protection, and maneuver—will be a flattened command, control, and intelligence structure that will permit the warfighter, at any level, to employ forces and mass effects in revolutionary ways.

In a broad sense, MOUT crosses all spectrums of general warfare: our combat forces must be able to fight and survive better than their adversaries. MOUT is unique because it is perhaps the most complex and resource-intensive environment in which they will have to fight.

B. OPERATIONAL CAPABILITY ELEMENTS

Urban centers increasingly are the sites of conflict throughout the world. MOUT is, and will continue to be, a major area of concern for U.S. forces. MOUT entails military actions that are planned for and conducted in terrain that features manmade infrastructure designed for habitation, cultural and recreational use, and economic activities by civilian population where tactical options might be complicated by the proximity of noncombatants. Actions involve small units, and the potential for incurring casualties is high. MOUT requires extensive use of Army and Marine light forces whose mission success tends to focus more on the operational effectiveness at lower echelons (e.g., battalion and below) than larger scale conflicts. The U.S. operational advantage—typically associated with long-range, high-technology weapon platforms that use mass and mobility—is significantly reduced in urban environments. Therefore, the system of choice for MOUT remains the individual warrior working within a small unit.

As for warfare in general, for MOUT the key operational capabilities are firepower, force protection, and maneuver. C^4I and the associated situation awareness enable each of the operational capabilities. Within these three broad areas, we have defined specific operational capability elements that, if achieved, will lead to a significant improvement in our capability to effectively operate in a MOUT environment.

Firepower. MOUT firepower will consist of a "system-of-systems" that enables our forces to locate the objective or target, provide responsive command and control, generate the desired

effect, assess the level of success, and retain the flexibility to reengage with precision when required. The specific operational capability elements are listed below.

- *Situation awareness.* The key to success in offensive operations in urban terrain is knowledge—knowledge of one's own position(s) and intent, and of the position(s) and intent of the enemy. That knowledge must be readily available at every level down to the individual warrior, regardless of whether he has line of sight to the source of the information.
- *Weapon effectiveness.* MOUT engagements require overmatching lethality in terms of direct and indirect firepower tailored to effectively engage targets commonly encountered in MOUT, using smart and precision-guided munitions. We must build on current U.S. advantages in delivery accuracy and all-weather and night capabilities. Moreover, we must foster the development of nonlethal technologies to provide selective response and the ability to minimize collateral damage.

Force Protection. MOUT force protection will enable the effective employment of our forces while degrading opportunities for the enemy. We must protect our own forces from the very technologies we are exploiting. Specific operational capability elements are:

- *Situation awareness.* Situation awareness will be built on information superiority, which will provide multidimensional and all-environment awareness and assessment as well as positive identification of all forces in the battlespace.
- *Weapon effectiveness.* A key to surviving in any environment is the ability to engage the enemy accurately and effectively in all conditions before he is able to engage us. A flexible response option such as nonlethal weapons will lessen the chance of indecision associated with noncombatants in the battlespace.
- *Individual protection.* If our warriors are to be successful in MOUT, they must survive. Individual systems that enhance survivability are essential to force protection.

Maneuver. MOUT maneuver is the ability to apply the multidimensional aspects of information superiority and the ability to insert forces where and when we want them to accomplish assigned tasks within the constraints of the urban environment.

- *Situation awareness.* The application of rapid, unpredictable yet precise insertion of the right forces at the right time without the knowledge of the enemy will enable the broader operational capability of maneuver. Situation awareness is one critical enabling ingredient.
- *Precision insertion.* Not only must we know where the enemy is, but we must be able to approach him from where he least expects it and when he least expects it—at night and in inclement weather.
- *Individual mobility.* The individual warrior must be able to move quickly and precisely, unencumbered by heavy and bulky body armor, weapon systems, and communications packages. His mobility—the ability to move vertically as well as horizontally—must be increased to allow him to engage where least expected The warrior also needs a lightweight, simple means to rapidly breach the walls, ceilings, and floors in order to enhance maneuverability and survivability by avoiding traditional passageways that are normally covered by fire, mined, or boobytrapped.

The goal is to enhance the operational capability elements mentioned above to increase the effectiveness of the individual warrior in the urban environment. Situation awareness is the major enabler that is essential to the effectiveness of each of these elements as shown in Figure VIII–1.

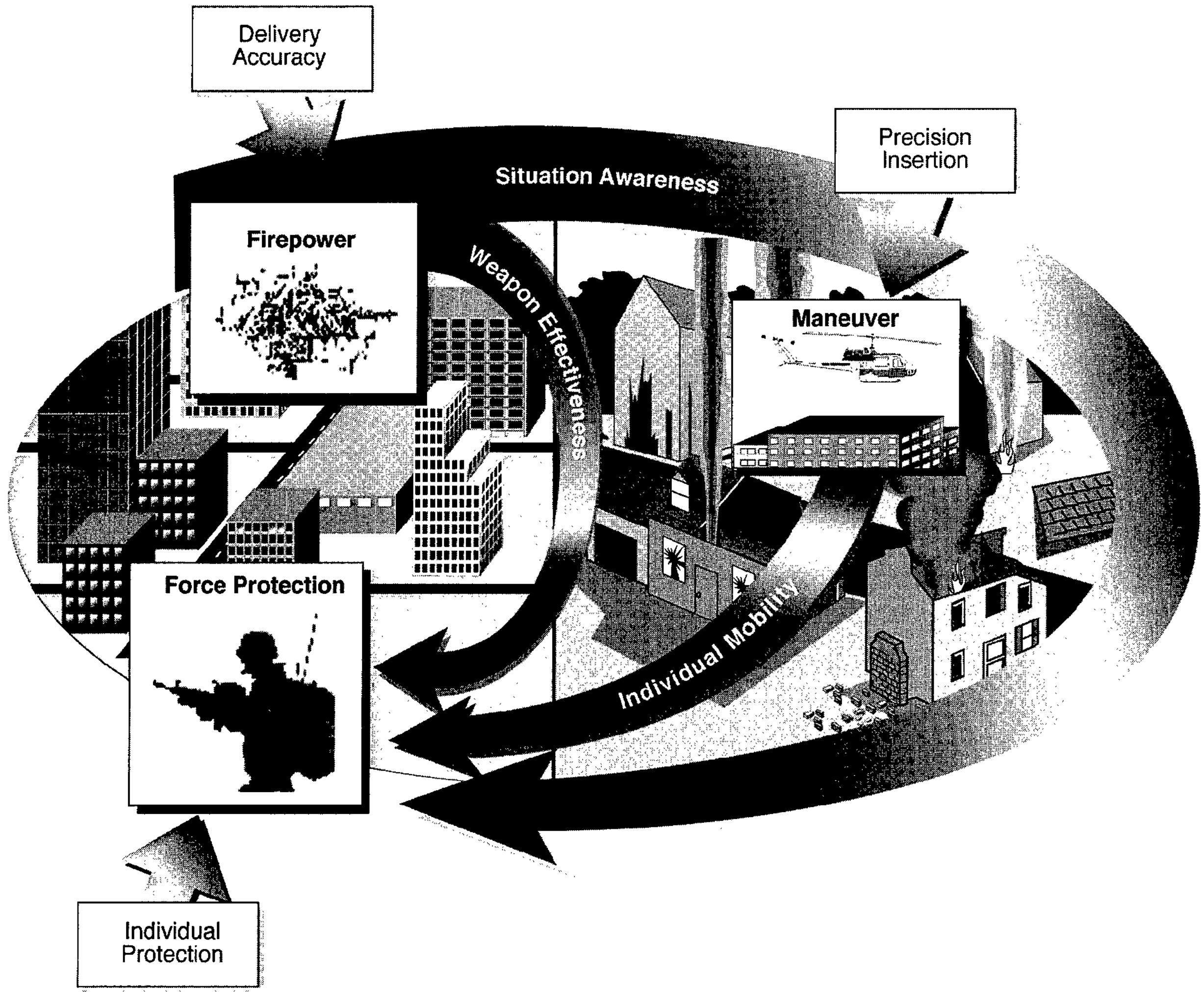


Figure VIII–1. Concept—Military Operations in Urban Terrain

C. FUNCTIONAL CAPABILITIES

To achieve the needed operational capabilities and to create a greater U.S. military advantage, MOUT requires, at a minimum, the functional capabilities described below and shown in Table VIII–1 as they relate to the operational capability elements.

Table VIII–1. Functional Capabilities Needed—Military Operations in Urban Terrain

	Operational Capability Elements							
	Firepower		Force Protection			Maneuver		
Functional Capabilities	Situation Awareness	Weapon Effectiveness	Situation Awareness	Weapon Effectiveness	Individual Protection	Situation Awareness	Precision Insertion	Individual Mobility
1. Ability To Accurately Place Self and Enemy With Complete Knowledge of Environment							●	
2. Flattened C^2I Structure Allowing Distribution of Essential Information to Every Level of Command Down to Individual Combatant	●		●			●		
3. Increased Individual Weapon Effectiveness Day/Night, All-Weather, Long Range With a Measured Response Capability		●		●				
4. Increased Crew-Served Weapon Effectiveness Against Fortified, Defilade, Dug-In Targets		●		●				
5. Enhanced Target Acquisition Indirect Viewing and Through-Wall Sensing	○	●	○	●		○		
6. Decreased Sensor-to-Shooter Engagement Time		●		●				
7. Hands-Free Communication		○		○				●
8. Lighter, Less Bulky Body Armor and Lighter Equipment and Compact Weapon Systems					●			●
9. Enhancements for Individual Combatant To Negotiate and Breach Obstacles					○			●
10. Ability To Differentiate Friend From Foe in Reduced Visibility/No Visibility	●	○	●	○	●	●		
11. Increased Capability To Detect Mines and Explosives	●				●	●		
12. Increase Capability To Target Snipers and Mortars	●	○	●	○	●			
13. Reduction of Multispectral Signature of Individual Combatant					●		○	○
14. Reduction of Susceptibility of Individual Combatant to Small Arms, Fragmentation, and Environmental Hazards Such as Fire and Chemical Sources					●			
15. Ability to Monitor and Transmit Physical Well-Being of Individual Combatant	○		○		●	○		
16. Precision, Survivable Clandestine Insertion of Combat Forces							●	
17. Ability to Control Individuals, Crowds, and Vehicles With Non-Lethal Capabilities		●			●			

● Strong Support ○ Moderate Support

Firepower. Improved individual and crew-served weapons with full-solution fire control, coupled with improved bunker-defeating weapon systems, will enhance target engagement capabilities against fortified, dug-in, or defilade targets. Multispectral sensors will provide enhanced target acquisition under all operational conditions. In addition, the sensor-to-shooter linkages will provide effective target handover to supporting standoff precision weapon systems. Irritants, barriers, and incapacitants will provide nonlethal capabilities to augment crowd control and deal effectively with the noncombatant population.

Force Protection. Improved small-arms protective vests will stop 7.62-mm armor-piercing rounds. Multispectral signature-reducing materials and techniques will reduce detection by enemy sensors. Lightweight, multifunctional protective materials will allow survival in flame and fires and other environmental threats and hazards. Combat identification, indirect viewing/unexposed firing, mine detection, anti-sniper and counter-sniper systems, and personnel status monitoring will also enhance survivability, as will overall improvements in situation awareness, particularly when digitally linked.

Maneuver. Self-contained navigation technologies capable of better than 3-meter accuracy for GPS augmentation, urban databases and digital mapping (better than 1-meter resolution), and simulations fed by the rapid generation of terrain, feature, and building data, will provide increased command tempo, control, intelligence, and mission planning and rehearsal, while enhancing maneuverability of individuals and the force. Precision clandestine personnel aerial delivery technologies capable of providing 25-meter circular error probable accuracy will heighten warrior mobility and survivability. Lightweight, rapidly emplaceable individual mobility tools will enhance the warrior's ability to move vertically and horizontally in and around buildings and other obstacles. These tools need to be offered in a variety of capabilities such as stealthy emplacement and a rapid shoot-through mode in order to defeat obstacles, open barriers/walls, and attack fortifications in an urban environment.

Advances in command, control, communications, computers, and intelligence (C^4I) capabilities will be required across each of the operational capability elements if we are to achieve the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010*. Near-real-time vertical and horizontal C^2 from the battalion down to the individual warrior will enhance situation awareness at all levels. This will be accomplished through hands-free, robust communications; high-data-rate communications for rapid voice, data, and video transmissions; and video capture. Fusing, filtering, and disseminating technologies will ensure that essential information is distributed to the appropriate small units. Near-real-time sensor-to-shooter linkages are needed to facilitate the processing and dissemination of data. Improved multispectral sensors and optics, combat identification systems, topographical systems, counter-sniper systems, unattended ground vehicles (UGVs) and unattended aerial vehicles (UAVs), and other emerging systems will be necessary to accommodate these near-real-time sensor-to-shooter linkages.

The 1996 DSB Summer Study identified three technology areas that must be exploited if we are to be successful in urban operations: virtual line of sight; precise location of friends, innocents, and foes; and the need for minimum or no collateral damage. Virtual line of sight could be enabled with through-the-wall sensor concepts, miniaturized UAVs and UGVs, or robots. Microbots could provide significant increases in functional capabilities for MOUT situation awareness. Robots could act as "point men" for force protection to precede our warriors and act in a sentry role to cover

building exits. Nonlethals would help the small urban force deal with innocents and avoid any unnecessary collateral damage. The principal issue is identifying the "acceptable limits of effects."

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

The operational capabilities required to be effective in the urban environment are identical to those for land warfare in general. They are just harder to achieve. The current U.S. military capability was developed to conduct large-scale, rural warfare in central Europe (Reference 16). Many current systems are not fully suited to the MOUT mission and environment. Heretofore, the U.S. military strategy and doctrine called for avoiding urban areas and controlling them from without. Our currently fielded capabilities are optimized for this wide-open land battle and do not adequately support warfare in the much more difficult urban environment. Table VIII–2 details the limitations and solutions for each of the operational capability elements.

Our warriors are unable to communicate through walls and other obstacles. They cannot determine their exact positions accurately enough, nor are they able to pinpoint targets for supporting arms. Urban databases do not exist from which they can draw to increase situation awareness. Warriors cannot determine the position of or defeat an enemy who chooses to remain covered. Individual equipment is bulky and heavy, and it degrades mobility in the often cramped urban environment. In addition, there is no capability to choose the type and degree of force to use, which puts noncombatants at risk and might inhibit the use of any force.

For the most part, technologies necessary to achieve the operational capabilities of MOUT firepower, force protection, and maneuver already exist either on the shelf or as short-term defense technology objectives in other JWSTP or DTAP technology areas. The challenge is to integrate these technologies into coherent interoperable systems optimized for MOUT.

Technological barriers exist that will have to be surmounted. For MOUT, these occur primarily in C^4I, an area that is key to situation awareness. The greatest concern is the limiting effects of urban environments on small-unit communications, reliability, and range. The technology does not currently exist, nor does a breakthrough appear imminent, that will allow the non-line-of-sight transmission (through obstacles) of the large bandwidths needed to carry necessary information to the individual warrior. Research will center on innovative new signal routing techniques and exploitation of low-frequency technology.

Table VIII–2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain

Goal	Functional Capabilities	Limitations	Key Technologies
Firepower			
Operational Capability Element: Situation Awareness			
Provide a system of systems that will enable our forces to locate the objective or target, provide responsive command and control, generate the desired effect, assess the level of success, and retain the flexibility to reengage with precision when required.	Ability to accurately place self and enemy with complete knowledge of environment Flattened C^2I structure allowing distribution of essential information to every level of command down to individual combatant	Ability to maintain accurate position coordinates over time Limiting effects of urban environments on communication reliability, range, and line-of-sight-dependent operations EMI and RF interference problems associated with tightly packaged combatant sensor, communication, and weapon systems See-through flat-panel displays of limited resolution Uncooled thermal sensors of limited resolution No available shared aperture IR/ radar sensor No available "smart ground station" processing capability Limitations presented at Figure IV–2 (Information Superiority) apply	Multichannel RF links Wireless networking Data compression technologies Real-time video Lightweight power technologies Electronics packaging Low-power electronics Microelectromechanical systems (MEMS) Advanced, lightweight multispectral sensors Lightweight, downrange wind sensing Advanced man–machine interfaces Automated artificial intelligence-assisted sensor/data fusion Systems miniaturization technologies High-bandwidth datalinks Smart remote/ground station processing with ATR Technologies listed in Figure IV–2 (Information Superiority) apply
Operational Capability Element: Weapons Effectiveness			
	Increased individual weapon effectiveness; day/night/all-weather long-range operation with a measured response capability Increased crew-served weapon effectiveness against fortified, defilade, dug-in targets Enhanced target acquisition capability—indirect viewing and through-wall sensing Decreased sensor-to-shooter engagement time	Uniform fragmentation distribution Stability of lightweight individual weapon platforms Accurate laser rangefinding in all environments Boresighting weapon-mounted sensors Cost, weight, and power for individual combatant acquisition, data processing, display, and weapon systems No available tunable (lethality selectable) nonlethal weapons/munitions Limited bioeffects database on personnel effects of nonlethal technologies	Multichannel RF links Electronics packaging Low-power electronics System miniaturization technologies High-bandwidth datalinks Lightweight, high-power density batteries/power cells Advanced materials Efficient recoil mitigation Accurate all-environment laser ranging techniques Lightweight optoelectronics Directed air-burst mechanisms Integrated range feedback with selectable lethality (nonlethal to lethal) munitions on a single weapon platform Variable-velocity weapon mechanisms Proximity fusing for antipersonnel use

Table VIII–2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Force Protection			
Operational Capability Element: Situation Awareness			
Provide the necessary systems to significantly increase personnel warfighter survivability in urban terrain	Ability to accurately place self and enemy with complete knowledge of environment Flattened C^2I structure allowing distribution of essential information to every level of command down to individual combatant Ability to differentiate friend from foe in reduced/no visibility Increased capability to detect mines and explosives Increased capability to target snipers and mortars Enhanced target acquisition capability—indirect viewing and through-wall sensing Decreased sensor-to-shooter engagement time	Ability to maintain accurate position coordinates over time Limiting effects of urban environments on communication reliability, range, and line-of-sight-dependent operations EMI and RF interference problems associated with tightly packaged combatant sensor, communication, and weapon systems Current flat-panel displays of limited resolution No available shared aperture IR/radar sensor No available "smart ground station" processing capability Limitations presented at Figure IV–2 (Information Superiority) apply Automated mine detection capabilities limited	Low-cost millimeter-wave radar Projectile detection/tracking algorithms processing Laser propagation RF antenna design/construction RF spread-spectrum signal transmission and processing Accurate all-environment laser ranging techniques
Operational Capability Element: Weapons Effectiveness			
	Enhanced target acquisition capability—indirect viewing and through-wall sensing Decreased sensor-to-shooter engagement time	Cost, weight, and power for individual combatant acquisition, data processing, display, and weapon systems No available tunable (lethality selectable) nonlethal weapons/munitions Limited bioeffects database on personnel effects of nonlethal technologies	Multichannel RF links Electronics packaging Low-power electronics System miniaturization technologies High-bandwidth datalinks Advanced materials Lightweight optoelectronics
Operational Capability Element: Individual Protection			
	Reduction of multispectral signature of individual combatant Reduction of susceptibility of individual combatant to small-arms fire, fragmentation, and environmental hazards such as fire and chemical sources Ability to monitor and transmit physical well-being of individual combatant	Lack of affordable, lightweight, flexible small arms materials Limited understanding of fundamental penetration mechanisms Independent component approach—not integrated The integration of thermal camouflage technology into a textile material Site-specific camouflage Electronics miniaturization and integration Lack of knowledge of appropriate essential elements of information Lack of personal medical sensors No automatic transmission of medical information Integration of low-cost flame protection technology into multifunctional textile materials	Electronics packaging Low-power electronics Advanced man–machine interfaces Automated artificial intelligence assisted sensor/data fusion Advanced materials Enhanced numerical modeling to understand fundamental penetration mechanisms Increased strength and low density materials Improved specific toughness, high modulus polymers Lightweight, flexible, multispectral textile materials Accurate medical sensors on individual

Table VIII–2. Goals, Limitations, and Technologies—Military Operations in Urban Terrain (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Maneuver			
Operational Capability Element: Situation Awareness			
The multidimensional application of information, engagement, and mobility capabilities to position and employ widely dispersed joint air, land, sea, and space forces to accomplish the assigned operational tasks	Ability to accurately place self and enemy with complete knowledge of environment Flattened C^2I structure allowing distribution of essential information to every level of command down to individual combatant	Ability to maintain accurate position coordinates over time Limiting effects of urban environments on communication reliability, range, and line-of-sight-dependent operations EMI and RF interference problems associated with tightly packaged combatant sensor, communication, and weapon systems Current flat-panel displays of limited resolution No available shared aperture IR/radar sensor No available "smart ground station" processing capability Limitations presented at Figure IV–2 (Information Superiority) apply	Multichannel RF links Wireless networking Data compression technologies Real-time video Lightweight power technologies Electronics packaging Low-power electronics MEMS Advanced, lightweight multispectral sensors Lightweight, downrange wind sensing Advanced man–machine interfaces Automated artificial intelligence-assisted sensor/data fusion System miniaturization technologies High-bandwidth datalinks Smart remote/ground station processing with ATR Technologies listed in Figure IV–2 (Information Superiority) apply
Maneuver (continued)			
Operational Capability Element: Precision Insertion			
Precision clandestine insertion of airborne combat forces	Precision, survivable clandestine insertion of combat forces	Accurate characterization of decelerator aerodynamic coefficients of performance Maneuvering around urban obstacles at night Gliding characteristics of parafoil	Multichannel RF links Computational fluid dynamics applications for decelerator characterizations Low-observable transport platform with short or vertical takeoff and landing capabilities
Operational Capability Element: Individual Mobility			
	Hands-free communications Lighter, less bulky body armor and equipment and compact weapon systems Enhancements for urban warrior to negotiate and breach obstacles	Helmet weight Current sensor technology dependent on full-time MITL teleoperation of UGVs Current sensor technology not size/weight/cost optimized for UGV applications Inability to capture and effectively user 100% of body's energy expenditure Heavy, short-lived power sources	Advanced man–machine interfaces Voice controlled communication and nondistracting control mechanisms Advanced materials Miniaturized propulsion Biomechanics and robotics Lightweight, long-life power sources

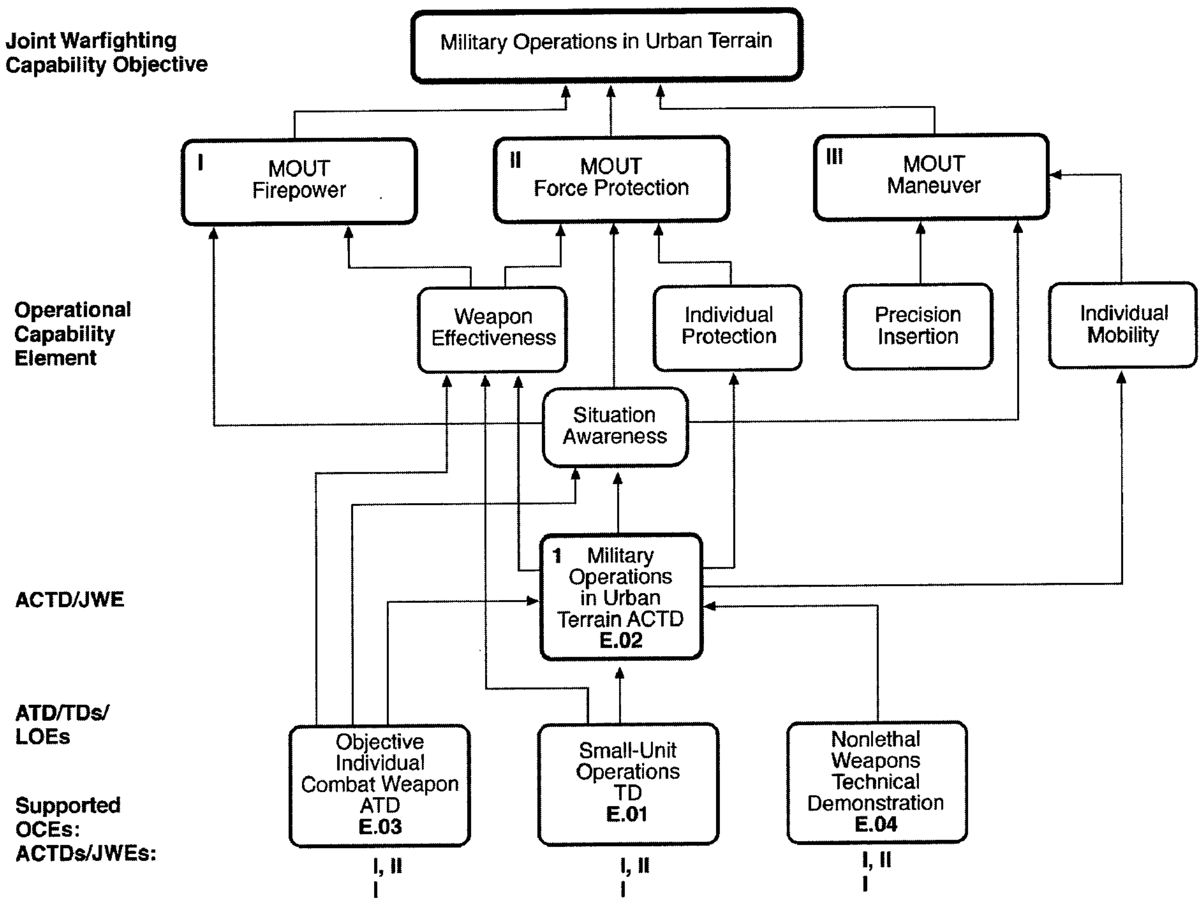
E. TECHNOLOGY PLAN

Tackling the challenges imposed by the MOUT environment is a formidable endeavor. As such, a four-component approach is undertaken to focus efforts on key challenges in a comprehensive manner. Each component is a primary DTO and will be ready for demonstration at a different point along the roadmap. The DTOs are described below:

- *E.01, Small-Unit Operations (SUO) TD,* effort will demonstrate the capability to provide scaleable, nonhierarchical networks with robust communications to enhance decision making at all echelons involved in MOUT operations.
- *E.02, Military Operations in Urban Terrain ACTD,* will focus primarily on the integration, linkage, and interoperability of MOUT system components, and will include demonstrations in joint field exercises. This ACTD provides the first opportunity to demonstrate a MOUT system-of-systems in the FY 1999–2000 timeframe. It will demonstrate available technology items (i.e., NDI/COTS/GOTS) during FY1998. This initiative cuts across the services and will capture the efforts of the Army, DARPA, Marine Corps, and U.S. Special Operations Command (USSOCOM).
- *E.03, Objective Individual Combat Weapon (OICW) ATD,* will demonstrate in FY99 affordable, high-payoff individual weapon system technologies that yield dramatically improved hit probability, lethality, and operational capability through the use of 20-mm air-bursting munitions. These technologies will affect decisively violent and suppressive target effects, providing an overmatch capability against threat systems. The air-bursting munitions will defeat difficult MOUT targets that the current systems cannot—for example, individuals within rooms, on rooftops, around corners, and behind vehicles. The OICW is the principal technology demonstration effort in the Joint Service Small Arms Master Plan and represents the next-generation individual weapon for all of the armed services (see also DTO WE.34.02, Objective Crew-Served Weapon).
- *E.04, Nonlethal Weapons Technology Demonstration,* will develop and demonstrate antipersonnel and antimaterial nonlethal devices, munitions, and weapons. Mission areas of priority include controlling crowds, localizing or dispersing noncombatants, denying an area to personnel or vehicles, and disabling vehicles, aircraft, vessels, facilities, and equipment. This capability is especially critical to the MOUT environment due to the stringent rules of engagement that often apply.

Figure VIII–2 depicts the integration of supporting technologies to achieve operational capabilities. Table VIII–3 lists the key DTOs, and Table VIII–4 shows the demonstrations supporting MOUT JWCOs.

The U.S. warfighter currently has basic capabilities for conducting the full spectrum of operational missions in most environments; however, there are significant deficiencies associated with MOUT. The intent of the MOUT technology plan is to provide a path for resolving those deficiencies and advancing critical technologies needed for MOUT. The group of functional capabilities identified here must be developed to ensure that the United States can overmatch any adversary in a conflict set in urban terrain. The roadmap for the development and demonstration of the MOUT system-of-systems is shown in Figure VIII–3.



Supporting ACTD, DTAP DTOs

A.06	Rapid Terrain Visualization ACTD
A.07	BADD ACTD
C.02	Combat ID ACTD
L.02	Surveillance and Tracking
L.08	Tactical Operations Support
M.06	Precision-Guided Mortar Munitions ATD
IS.40.01	Individual Combatant and Small-Unit Operations Simulation
MP.05.01	Protective Materials for Combatants

HS.05.05	Ballistic Protection for Individual Survivability
HS.10.05	Force XXI Land Warrior
HS.12.02	Helmet-Mounted Sensory Ensemble
HS.17.05	Panoramic Night Vision Goggle Technology
HS.18.02	Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel
HS.19.05	Rotorcraft Pilot's Associate ATD
HS.25.05	Multifunctional Fabric System

M.02	Extending the Littoral Battlespace ACTD
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing
SE.09.02	Multiwavelength, Multifunction Laser
SE.28.01	Low-Power Radio Frequency Electronics
SE.33.01	Advance Focal Plane Array Technology
SE.38.01	Microelectro-mechanical Systems
SE.68.01	Rapid Mapping Technology
WE.34.02	Objective Crew-Served Weapon

Figure VIII–2. Technology to Capability—Military Operations in Urban Terrain

**Table VIII–3. Defense Technology Objectives—
Military Operations in Urban Terrain**

DTO No.	Title
E.01	Small-Unit Operations TD
E.02	Military Operations in Urban Terrain ACTD
E.03	Objective Individual Combat Weapon ATD
E.04	Nonlethal Weapons Technical Demonstration
A.06	Rapid Terrain Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
C.02	Combat Identification ACTD
L.02	Surveillance and Tracking
L.08	Tactical Operations Support
M.02	Extending the Littoral Battlespace ACTD
M.06	Precision-Guided Mortar Munitions ATD
HS.05.05	Ballistic Protection for Individual Survivability
HS.10.05	Force XXI Land Warrior
HS.12.02	Helmet-Mounted Sensory Ensemble
HS.17.05	Panoramic Night Vision Goggle Technology
HS.18.02	Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel
HS.19.05	Rotorcraft Pilot's Associate ATD
HS.25.05	Multifunctional Fabric System
IS.40.01	Individual Combatant and Small-Unit Operations Simulation
MP.05.01	Protective Materials for Combatant and Combat Systems Against Conventional Weapons
SE.06.01	Multifunction Electro-Optical Sensors and Signal Processing
SE.09.02	Multiwavelength, Multifunction Laser
SE.28.01	Low-Power Radio Frequency Electronics
SE.33.01	Advanced Focal Plane Array Technology
SE.38.01	Microelectromechanical Systems
SE.68.01	Rapid Mapping Technology
WE.34.02	Objective Crew-Served Weapon

Table VIII–4. Demonstration Support—Military Operations in Urban Terrain

Demonstration	Operational Capability Elements: Fire Power: Situation Awareness	Fire Power: Weapons Effectiveness	Force Protection: Situation Awareness	Force Protection: Weapons Effectiveness	Force Protection: Individual Protection	Maneuver: Situation Awareness	Maneuver: Precision Insertion	Maneuver: Individual Mobility	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD	TD	LOE
Small-Unit Operations TD*	●		●			●			DARPA	E.01			X	
Military Operations in Urban Terrain ACTD*	●	●	●	●	●	●		●	Joint	E.02	X			
Objective Individual Combat Weapon ATD*	○	●	○	●				○	Joint	E.03		X		
Nonlethal Weapons Technical Demonstration*		●		●					USMC, Army	E.04				X
Rapid Terrain Visualization ACTD*	●		●			●			Joint	A.06	X			
Battlefield Awareness and Data Dissemination ACTD	●		●			●			DARPA	A.07	X			
Combat Identification ACTD	●		●		●	●			Joint	C.02	X			
Surveillance and Tracking	●					●			Joint	L.02				
Tactical Operations Support	○		○			○			Joint	L.08				
Extending the Littoral Battle-space ACTD	●	●	●			●			Navy, USMC, DARPA	M.02	X			
Precision-Guided Mortar Muni-tions ATD		●		●					Army	M.06		X		
Ballistics Protection for Individ-ual Survivability					●			●	Army	HS.05.05			X	
Force XXI Land Warrior*	●	●	●	●	●	●		●	USMC, Army	HS.10.05			X	
Helmet-Mounted Sensory Ensemble							○	○	Air Force, Navy	HS.12.02		X		
Panoramic Night Vision Goggle Technology	○	○	○	○		○	●	●	Air Force, Navy	HS.17.05		X		
Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel							●		Army	HS.18.02			X	
Rotorcraft Pilot's Associate			○	○		○	●		Army	HS.19.05		X		
Multifunctional Fabric System					●				Joint	HS.25.05			X	
Individual Combatant and Small-Unit Operations Simula-tion				○			○	○	Army, USMC	IS.40.01			X	
Protective Materials for Com-batant and Combat Systems Against Conventional Weapons					●			●	Army, Navy	MP.05.01			X	

*Strong support for counterterrorist operations ● Strong Support ○ Moderate Support

Table VIII–4. Demonstration Support—Military Operations in Urban Terrain (continued)

	Operational Capability Elements									Type of Demonstration				
	Fire Power		Force Protection			Maneuver								
Demonstration	Situation Awareness	Weapons Effectiveness	Situation Awareness	Weapons Effectiveness	Individual Protection	Situation Awareness	Precision Insertion	Individual Mobility	Service/ Agency	DTO	ACTD	ATD	TD	LOE
Multifunction Electro-Optical Sensors and Signal Processing	●		●		●	●			Army, Air Force	SE.06.01			X	
Multiwavelength, Multifunction Laser	○	●	○	●		○		○	Joint	SE.09.02			X	
Low-Power Radio Frequency Electronics	○		○			●		●	DARPA	SE.28.01			X	
Advanced Focal Plane Array Technology	●	●	●	●		●			Army, Navy	SE.33.01			X	
Microelectromechanical Systems	●		●			●			Army, Air Force, DARPA	SE.38.01			X	
Rapid Mapping Technology			○		○	●		●	Army	SE.68.01			X	
Objective Crew-Served Weapon		●		●					Joint	WE.34.02			X	

*Strong support for counterterrorist operations ● Strong Support ○ Moderate Support

The technologies required to achieve the functional and operational capability elements that are critical for MOUT are at varying levels of maturity. They will be demonstrated at the component, subsystem, and system level primarily through the completion of the DTAP DTOs (see Table VIII–3). The full suite of products and functionality that evolves from these technologies is required for seamless operation in a MOUT environment. To maximize our warfighting edge, these technologies must be integrated into a MOUT system-of-systems.

One of the greatest technical challenges for MOUT is the integration of a wide range of equipment, which will operate effectively and reliably given the particular challenges of the urban environment. In addition, integration of much of this equipment onto the human platform—with all its peculiarities, variations, and individual preferences—is critical, given that most MOUT operations focus on the individual warrior and small units. Experience has shown that a systems approach must be aggressively pursued, as opposed to a "stovepipe" development of each technology component. This is a key objective for the MOUT ACTD.

As seen in Figure VIII–3, various projects feed into these objective areas. Service and Defense Advanced Research Projects Agency (DARPA) ATDs and TDs will develop the new technologies, and most of the efforts provide for demonstration of those technologies. The primary focus of a few key programs (e.g., DARPA SUO, Army/Force XXI Land Warrior (FXXILW)) is on integrating subsystems, systems, and functionality for the warfighter. These programs are the "cement" that will form the cornerstone of the MOUT system-of-systems. Figure VIII–4 shows how the major infantry integration programs are linked together.

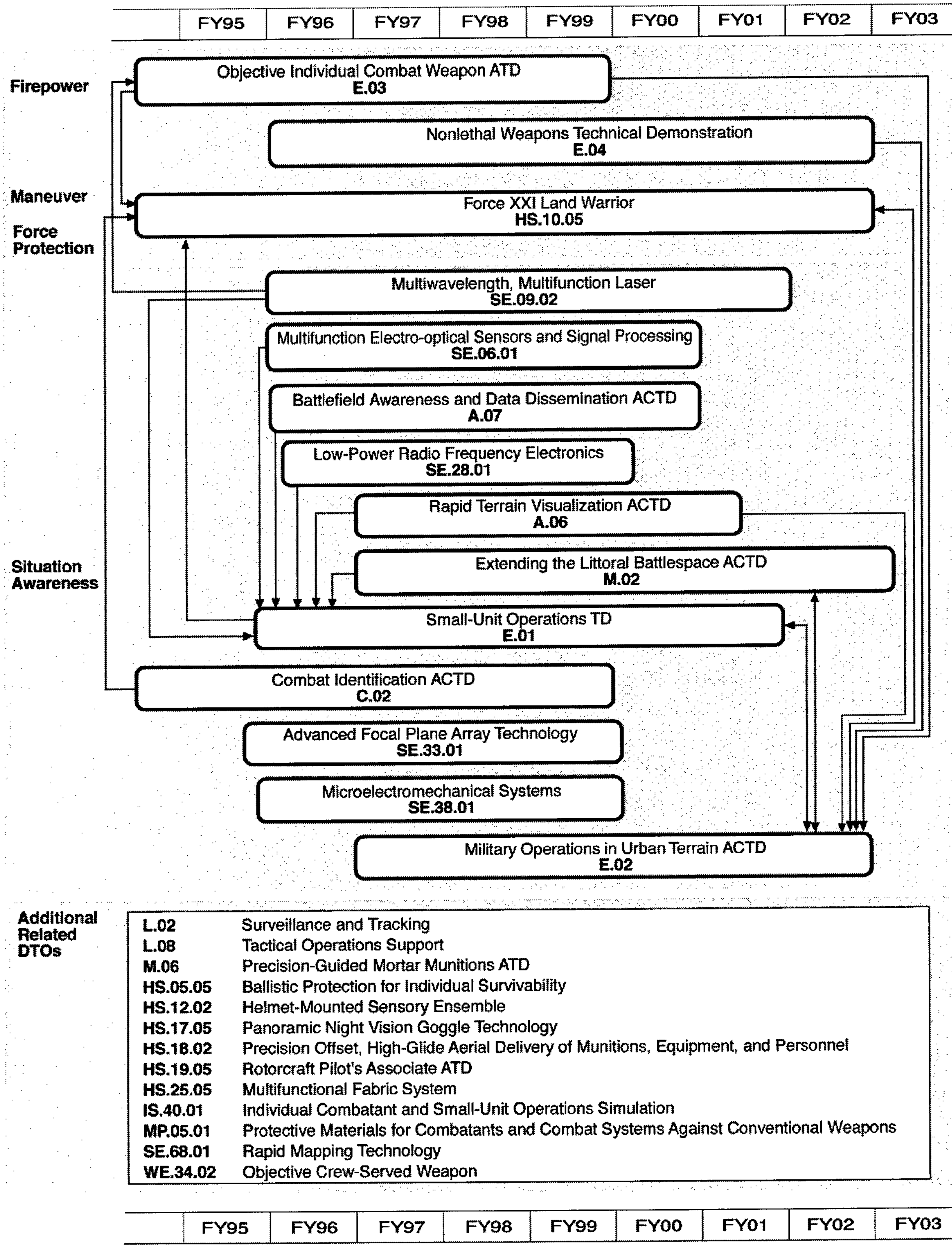


Figure VIII–3. Roadmap—Military Operations in Urban Terrain

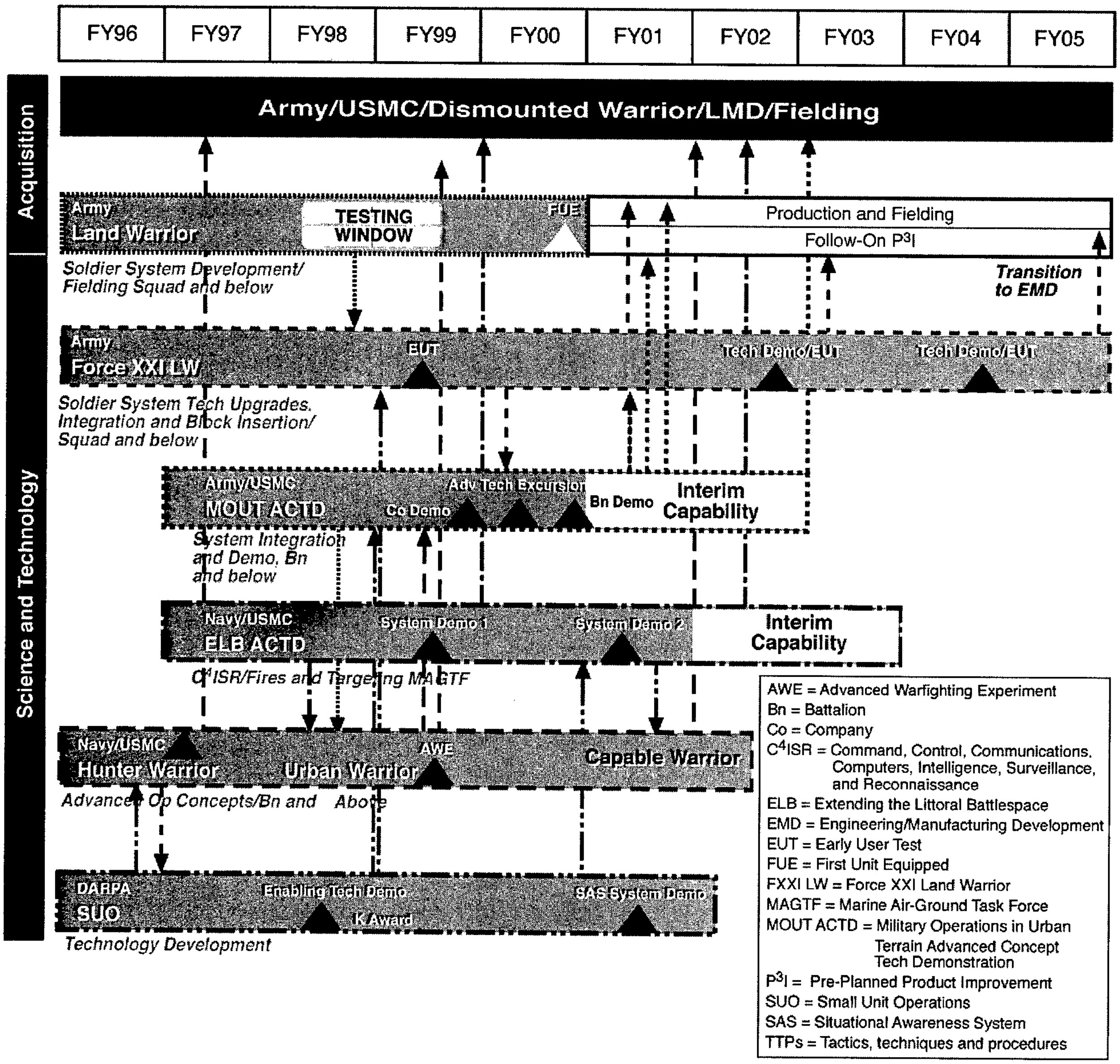


Figure VIII–4. Relationship of Major Infantry Programs

While not a functional capability directly contributing to any of the operational capability elements, modeling and simulation (M&S) will contribute to the assessment of advanced technologies as well as contributing to MOUT mission rehearsal. M&S will complement hardware and system development via an instrumented MOUT testbed. Coupled with upgraded models and simulations, this capability will be used to assess and evaluate hardware and software performance. M&S will also augment the development and assessment of advanced operational concepts and tactics, techniques, and procedures for MOUT operations, in addition to providing a mission rehearsal capability. In aggregate, the M&S effort will allow full operational exploitation of the technological advances.

Figure VIII–4 depicts the relationship of the major ground warfighter-related system developments. Lessons-learned from recent military operations in Bosnia, Macedonia, Haiti, and Somalia

have highlighted the need to comprehensively address the needs of the infantry across the services. The ability to provide an overmatch capability does not exist for infantry forces. For example, any potential adversary can procure the same items that are provided to our warfighters. This gap in overmatch capability places our forces at substantial risk. Due to increased complexities of the post–cold war environment, a coordinated division of the associated challenges is an effective way to address shortcomings in military preparedness for today's as well as tomorrow's military threats.

There is no single answer to this complex problem. Several dimensions of the problem require attention: cross-service as well as unique service requirements, immediate versus long-term needs, level of technological risk, materiel versus operational/doctrinal focus, echelon of application (e.g., individual warfighter or battalion and above), and operational basing (e.g., ground, sea, air). As a result, DoD has adopted a multipronged approach to concurrently tackle different portions of the total MOUT operational challenge facing joint combat forces.

This approach ensures that military requirements of dismounted warfighters are being addressed simultaneously in an integrated fashion. In addition, it ensures that adequate attention is given to key challenges in a logical and focused manner to increase overall operational effectiveness. The approach divides the complex challenges into manageable, separable efforts, balancing technological initiatives with advances in operational concepts to address a wide range of MOUT-related problems. Each effort is focused on overcoming specific portions of the total challenge.

The Ground Warfighter Program Integration Council (PIC) was formed in FY97 to ensure appropriate couplings between these programs. Organizations represented in the PIC include Office of Science and Technology/United States Special Operations Command; U.S. Marine Corps Extending the Littoral Battlespace Advanced Concept Technology Demonstration; U.S. Army Training and Doctrine Command Dismounted Battlespace Battle Laboratory and TRADOC System Manager–Soldier; Secretary of the Army, Research, Development, and Acquisition; Joint Staff (J8); OSI/Marine Corps Combat Developments Command; Soldier Systems Command Natick Research, Development, and Engineering Command and PM–Soldier; Army Digitization Office; Army Materiel Command; Office of Naval Research; Defense Advanced Research Projects Agency Small Units Operations PM; U.S. Marine Corps/Marine Corps Warfighting Laboratory; and Headquarters Department of the Army, Office of Deputy Chief of Staff for Operations and Planning.

The PIC is the catalyst for coherent program collaboration. The PIC objectives are as follows:

- Develop, maintain, and present coordinated and coherent program objectives and schedules.
- Disseminate information between and among programs to increase leverage and performance.
- Provide a forum to preclude programmatic duplication, integrate activities among the member programs, and resolve issues.
- Provide a forum to achieve synergy between programs.
- Identify and resolve issues, forwarding unresolved issues to the DDR&E chartered Warrior Systems Technology Base Executive Steering Committee or other formal councils as appropriate.
- Provide a forum to ensure that the programs yield a consistent, joint architecture.

The major efforts involved are the Extending the Littoral Battlespace (ELB) ACTD, Urban Warrior AWE, Land Warrior, Force XXI Land Warrior (FXXILW), Small Unit Operations (SUO), and MOUT ACTD. ELB and Urban Warrior include naval efforts addressing operational needs of forces to maneuver at sea and selectively project into urban areas. The ELB ACTD addresses the unique C^4ISR problems faced by the Navy/Marine Corps team—fighting a battle as a Naval Task Force, using sea-based Marines ashore and Navy ships at sea. The Urban Warrior AWE, the second phase of the Marine Corps' 5-year experimentation plan, is designed to address service-wide warfighting requirements for the Marine Air–Ground Task Force (MAGTF), as sea-based naval power projection forces employing ship-to-objective maneuver. The solutions will include changes in Marine Corps doctrine, organization, training, equipment, and support (DOTES) for urban terrain problems. Materiel solutions will be accelerated through the Marine Corps concept-based requirements process and the standard acquisition system.

The Army's Land Warrior program will field a dismounted soldier warfighting system and provides a platform and mechanism where MOUT enhancements for close combat can undergo transition for further engineering development, if needed, or insertion into production. FXXILW is the S&T arm of the LW program providing technology risk reduction as well as advanced technology components for insertion into the LW system. It also provides the path for future technology upgrades from other programs within the context of an overall P^3I for LW.

The DARPA SUO effort focuses on leap-ahead, high-risk technologies in the communications, geolocation, and situational awareness areas that will provide evolutionary architectural changes for future block upgrades into appropriate acquisition programs. The communications and geolocation technologies are focused on assured operations in restrictive (urban, mountainous, forested) non-line-of-sight and hostile low probability of detection (LPD), low probability of intercept (LPI), and antijam (AJ) environments. These technologies will be demonstrated in an integrated situational awareness subsystem (SAS). Successful technologies in SUO will undergo transition to the FXXILW effort for insertion into LW for fielding or into other acquisition programs, as appropriate.

The Army/Marine Corps MOUT ACTD is the venue to integrate and demonstrate mature and advanced technical and operational solutions to 33 specific user requirements to improve the operational effectiveness of soldiers and Marines at echelons at battalion or below, operating in urban or built-up areas. All the MOUT ACTD technical solutions are leveraged from ongoing R&D efforts, including LW/FXXLW and SUO, and from commercial and government off-the-shelf products. THE MOUT ACTD focuses on the integration of these solutions into a system-of-systems. The tight linkage of technology enhancements into a system coupled with user operational concepts will enable the MOUT ACTD to assess the military utility of the individual/collective solutions, and to effect the transition of promising technologies to the appropriate acquisition program.

The programs discussed above support general Special Operations Forces (SOF) requirements. However, SOF-specific requirements are covered separately by Program 11 technology and acquisition efforts.

F. SUMMARY

Accomplishment of the objectives delineated in each of the MOUT DTOs reflects the integration of capabilities within a given operational area. These DTOs are, in effect, waypoints on

the path to achieving a full spectrum of enhanced operational capability elements in MOUT. Each DTO represents a complement of interim capabilities within that specific area. The MOUT ACTD will complete the integration, interoperability, and linkage across many of these operational areas to achieve the full-spectrum, seamless MOUT capability, as illustrated in Figure VIII–5. The successful implementation of this technology plan will result in substantial improvements in the ability of U.S. forces to effectively and efficiently accomplish missions, including general war, contingency operations, counterinsurgency, and peace and humanitarian operations in built-up areas.

Measures of success will serve as quantitative goals for the MOUT ACTD. Although not defined for all potential technologies, the overall measures of success are defined in terms of percent

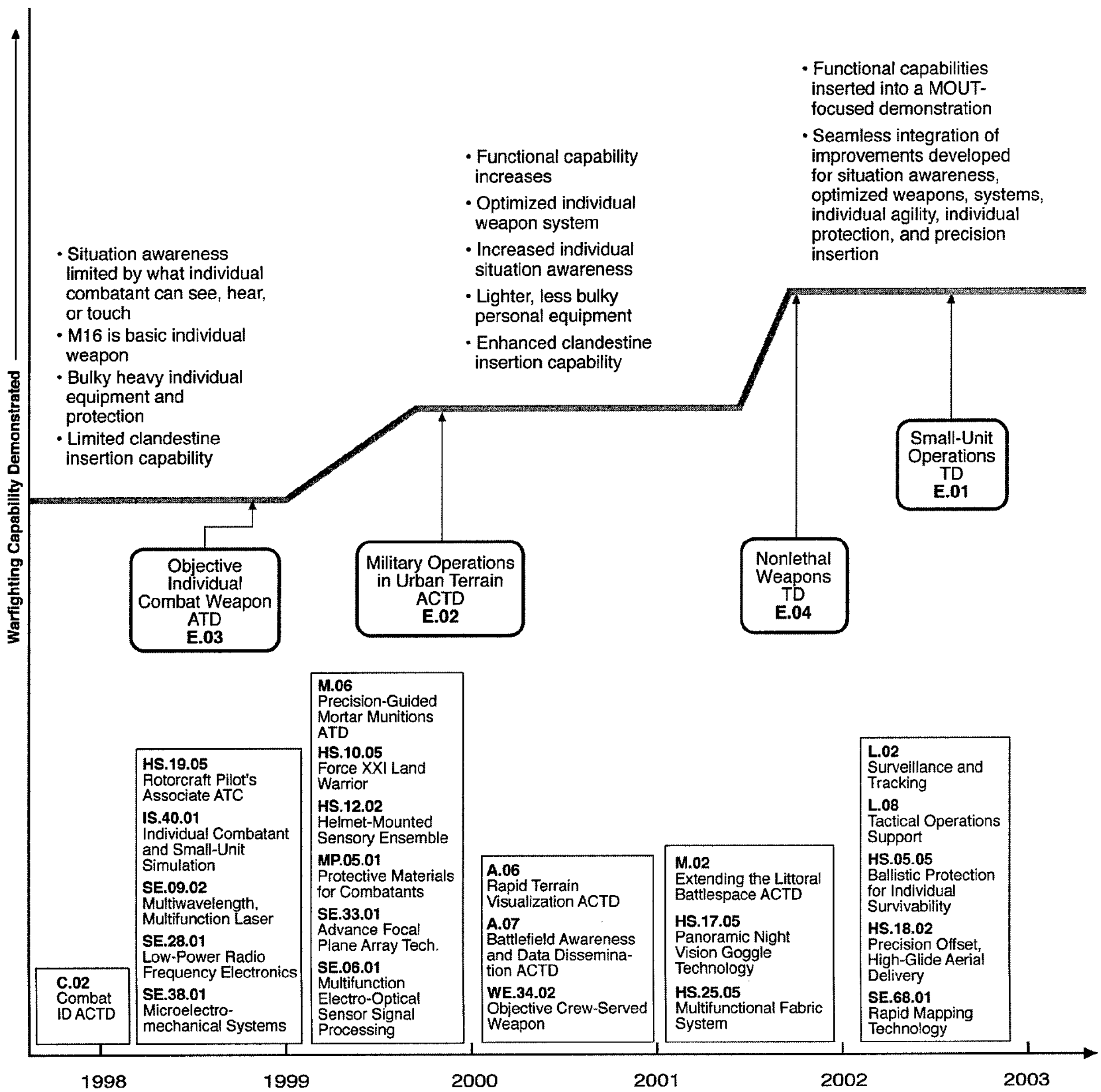


Figure VIII–5. Progress—Military Operations in Urban Terrain

improvements over the baseline MOUT capabilities, and applicable doctrinal and technical publications. Specific measures of effectiveness (MOEs) are in the areas of lethality, survivability, force protection, maneuver, C^4I, and unit/individual acceptance. Measures of performance (MOPs) for technology components will be developed and refined using the model-test-model methodology. The base case will be modeled using CASTFOREM, the Joint Training Simulator (JTS), or other models incorporating the anticipated field experiment, terrain, and scenario. Based on runs of the base case and the ACTD case, specific data on MOEs and MOPs can be predicted with defensible analytical underpinnings.

CHAPTER IX

JOINT READINESS AND LOGISTICS, AND SUSTAINMENT OF STRATEGIC SYSTEMS

CHAPTER IX
JOINT READINESS AND LOGISTICS, AND SUSTAINMENT OF STRATEGIC SYSTEMS

A. DEFINITION

The JWCO definition of *Joint Readiness and Logistics* is as follows:

> Joint Readiness and Logistics is the capability to enhance Readiness and Logistics for Joint and combined operations. This includes capabilities for enhanced simulation for training; improved and affordable O&M life cycle costs; mobility and sustainability (i.e., transportation support technologies, speed to delivery) and near-real-time visibility of people, units, equipment, and supplies which are in storage, in process, in transit, or in theater, linked with the ability to act on this information.

This year, this chapter of the *Joint Warfighter Science and Technology Plan* has been expanded to address Sustainment of Strategic Systems as well. For ease of discussion, each of the three elements of this chapter—Joint Readiness, Real-Time Focused Logistics, and Sustainment of Strategic Systems—is addressed separately within each of the chapter sections.

Concepts for Joint Readiness, Real-Time Focused Logistics, and Sustainment of Strategic Systems are presented in Figures IX–1, IX–2, and IX–3, respectively. These figures depict operational capability elements and the functional capabilities necessary to achieve JWCOs for these technology areas. A discussion of specific capability elements appears in Section B.

Other JWCOs also make significant contributions to achievement of the goals of readiness, logistics, and sustainment (e.g., the S&T reported in the Information Superiority chapter). In the interest of reducing redundancy, most of this program information is not repeated in this chapter.

1. Joint Readiness

Joint Readiness includes capabilities for enhanced simulation and information technologies for training, mission planning and rehearsal, assessment of force readiness, and readiness of the industrial base. The CJCS-approved Universal Joint Task List (UJTL) supports the readiness tasks that must be accomplished within the Joint Warfighting arena. The UJTL is broken down into operational and functional capabilities that are in the CINC's domain. If a combatant command has the means to accomplish all of the joint mission-essential tasks derived from the UJTL, then by definition the assigned forces have achieved a high state of readiness.

The concept of Joint Readiness is depicted in Figure IX–1.

2. Real-Time Focused Logistics

JCS Publication 1–02 (Reference 11) defines *Logistics* as

> The science of planning and carrying out the movement and maintenance of forces. In its most comprehensive sense, the aspects of military operations which deal with design and development, acquisition, storage, movement, distribution,

maintenance, evacuation, and disposition of materiel; movement, evacuation, and hospitalization of personnel; acquisition or construction, maintenance, operation, and disposition of facilities; and acquisition or furnishing of services.

According to *Joint Vision 2010*, Focused Logistics is the fusion of information, logistics, and transportation technologies to provide rapid crisis response, to track and shift assets even while en route, and to deliver tailored logistics packages and sustainment directly at the strategic, operational, and tactical level of operations. Focused Logistics is fully adaptive to the needs of our increasingly dispersed and mobile forces, providing support in hours or days versus weeks. It will enable joint forces of the future to be more mobile, versatile, projectable, and sustainable from anywhere in the world. It envisions a logistics system that is more responsive, flexible, and precise; and an environment where the military services and defense agencies work with the civilian sector to take advantage of advanced business practices, commercial economies, and global networks.

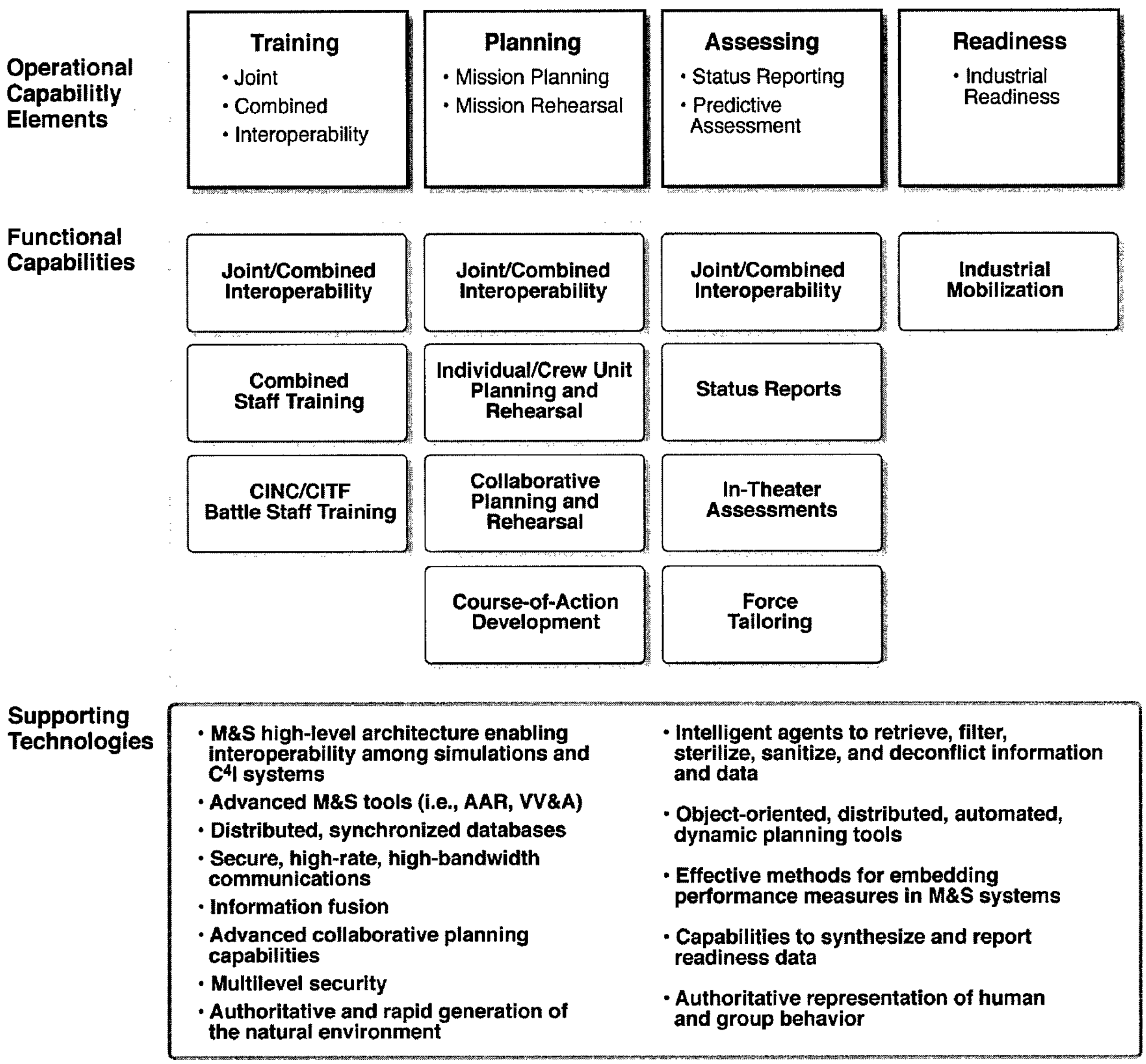


Figure IX–1. Concept—Joint Readiness

Technologies being pursued and described in this chapter will enhance airlift, sealift, and pre-positioning capabilities to lighten deployment loads, assist pinpoint logistics delivery systems, and extend the reach and longevity of systems currently in the inventory. The combined impact of these improvements will be a smaller, more capable deployed force that will require less continuous support with a smaller logistics footprint, decreasing the vulnerability of our logistics lines of communication.

Also included in this chapter are telemedicine technologies that apply physiological and medical knowledge to facilitate operational and medical decision making, enhance medical training, and enable delivery of medical treatment across all barriers. These improvements will enhance force protection, reduce time to critical intervention for injured personnel, improve the skills and efficiency of medical personnel, and improve the quality of emergency medical and surgical care throughout the battlespace while decreasing the far-forward footprint.

The technology enhancements discussed in this chapter support the Focused Logistics goals set forth in the CJCS's *Joint Vision 2010*. They will enhance logistics and health service support of joint and combined operations; improve and make affordable operations and maintenance (O&M) and life-cycle costs; improve mobility and sustainability; provide near-real-time visibility of equipment and supplies that are in storage, in process, or in transit; and provide the near-real-time status of personnel and units, either in CONUS or in theater. With respect to health services, these technologies will enhance the real-time visibility of personnel and units to provide the timely delivery of essential medical treatment. Technologies will also provide the linkage and ability necessary to act on this information.

The concept of Real-Time Focused Logistics is depicted in Figure IX–2.

3. Sustainment of Strategic Systems

Sustainment of Strategic Systems is the capability to sustain and upgrade existing strategic systems and to engineer, design, and develop strategic systems. Contributing factors include maintaining system safety; reducing O&M costs; increasing service life of existing systems; reducing reliance on testing via advanced computing and simulation, advanced technologies and advanced diagnostics/prognostics; and retaining the engineering core competency for retrofits and replacement of materials unique to strategic systems. As addressed in this chapter, Sustainment of Strategic Systems involves S&T activities directed at the unique requirements associated with this area. Sustainment of Strategic Systems is unique in that, for the first time in a half-century, no new strategic delivery systems or nuclear weapons are under development.[1] This is in contrast to other types of military capabilities, where ongoing development efforts ensure that core technical competencies are maintained and advanced. Underground nuclear testing, which previously played critical roles in developing new weapons and in validating the survivability of strategic systems, has ceased. Planning anticipates a comprehensive test ban treaty.

[1] The Department of Defense and Department of Energy have, however, retained the technical capabilities needed to modify existing strategic weapons and delivery systems to make them more responsive to new mission requirements. This was recently demonstrated through modification of the B61 nuclear bomb to produce the B61–11 earth-penetrating weapon that can be carried by existing strategic aircraft. Notwithstanding this qualification, the key point holds—for the first time since the mid 1940s, no new strategic delivery systems or nuclear weapons are under development.

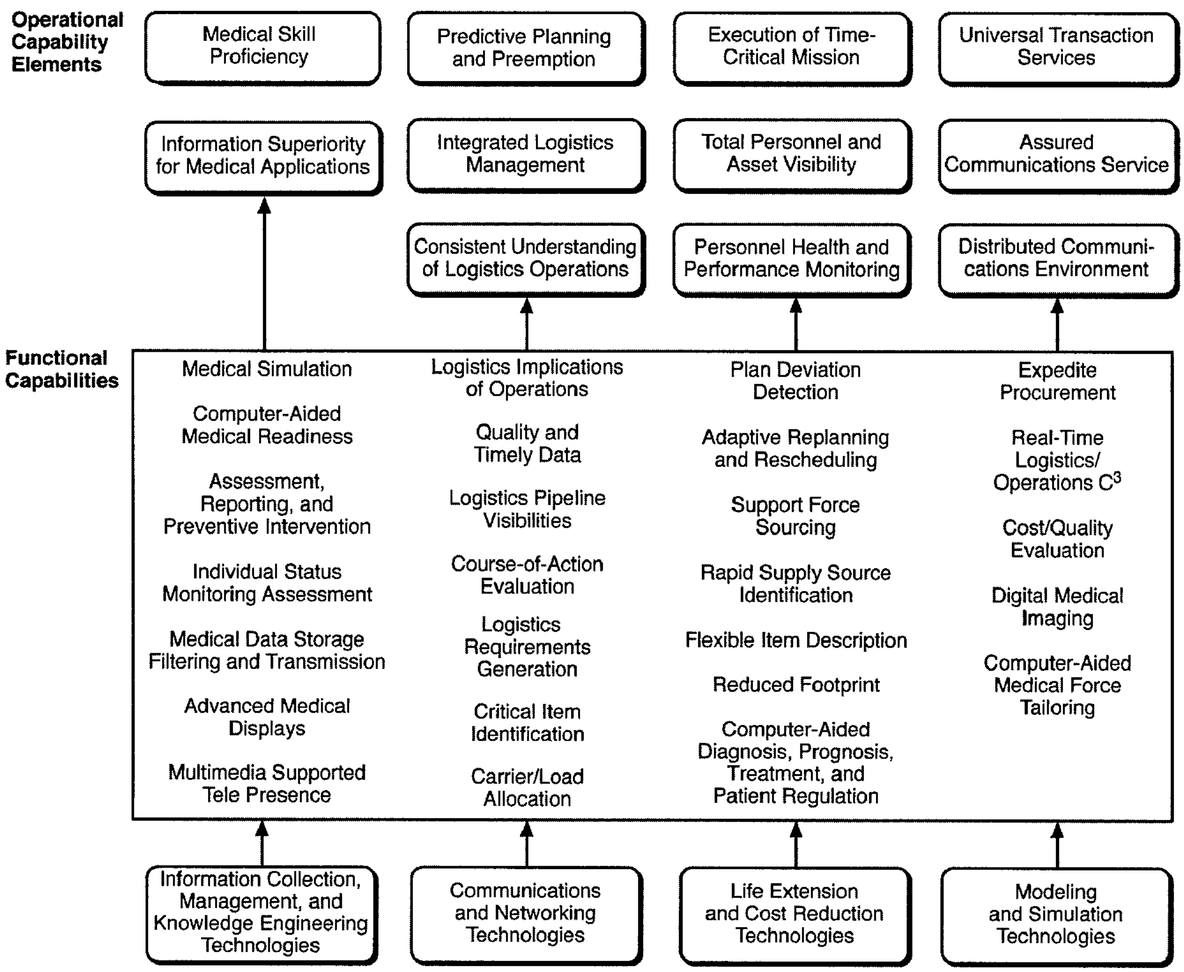


Figure IX–2. Concept—Real-Time Focused Logistics

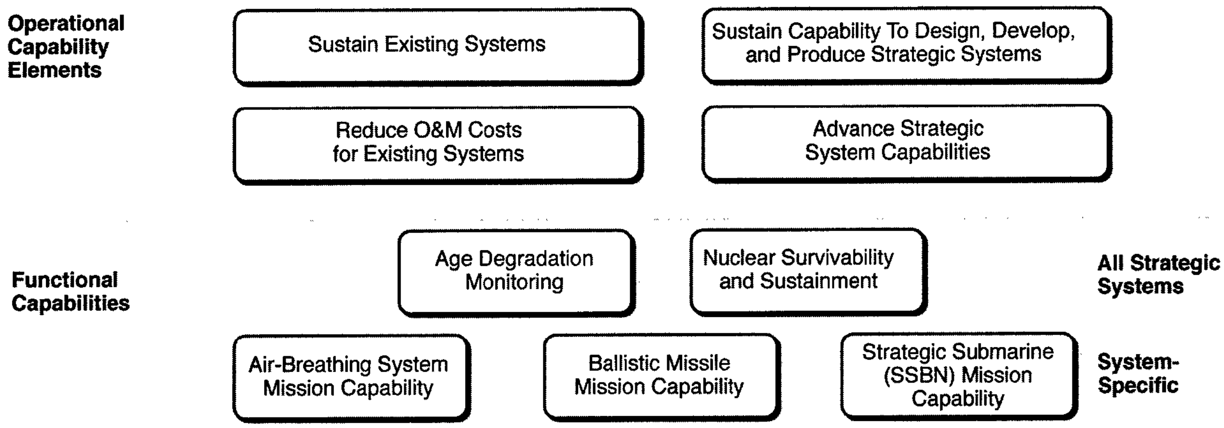
DoD is not the sole agency responsible for strategic nuclear systems.[2] Public law, notably the Atomic Energy Acts of 1946 and 1954, as amended, assigns responsibilities for national nuclear capabilities to the Department of Energy and the Department of Defense. DOE is responsible for the design, production, and end-of-service-life disposition of nuclear warheads. DoD is responsible for the other facets of national nuclear capability, including definition of military requirements for warheads, delivery systems, operational deployment of forces, and the ensemble of end-to-end capabilities needed for the planning and conduct of operations by nuclear forces.

The Quadrennial Defense Review (QDR) (Reference 7) concluded that: "... the policy and strategy to maintain our nuclear forces are still correct and needed." *Joint Vision 2010* expressed the same conclusion, stating that "America's strategic nuclear deterrent... will likely remain at the core of American national security." Sustainment activities ensure preservation of core technical

[2] For more information on DoD/DOE cooperative sustainment programs and DoD activities outside the S&T program directed at strategic system sustainment, see Reference 17, *Nuclear Weapon Systems Sustainment Programs,* a 1997 Secretary of Defense report to Congress available on the World Wide Web (http://www.defenselink.mil/pubs/dswa/).

capabilities that, in the absence of new development programs, might otherwise be at risk. These sustainment activities ensure the ability to maintain the required strategic forces.

The concept of Sustainment of Strategic Systems is depicted in Figure IX–3.



Current Strategic Systems	71 B-52s 21 B-2s	500 MM IIIs 50 Peacekeepers	18 Ohio class submarines each carrying 24 SLBMs
Strategic Posture in 2003, if START II is implemented	Same number of bombers; reduction in cruise missile capability of B-52 to remain within treaty limits	500 MM IIIs modified to carry a single warhead	14 Ohio class submarines each carrying 24 SLBMs

Figure IX–3. Concept—Sustainment of Strategic Systems

B. OPERATIONAL CAPABILITY ELEMENTS

1. Joint Readiness

Our national military strategy has changed from one of a forward-deployed ground force presence to one of primarily CONUS-based forces that must respond rapidly to joint combined operations anywhere in the world. As a result, it is important not only to demonstrate multiorganization interoperability for deployment of forces on specific missions to any place in the world, but also to demonstrate that those forces, their backup, and needed sustainment can be delivered to the right place at the right time to support or sustain missions. Therefore, it is necessary to improve our ability to know, in near-real time, the location, physical status, and training status of each person; the location, manufacturing status, and completeness of each piece of equipment; the location and consumption rate of each item of supply; and the location and state of readiness of each unit. This requires improved, large-scale accounting for inventory; status monitors on people, equipment, and cargo shipments; and near-real-time accessibility of this massive information data network for deployment and sustainment decisions. The technical objectives affecting the operational capabilities of joint, combined, and interoperability training; mission planning and rehearsal; and the readiness

assessment and status reporting deal primarily with the ability of the CINC and the Commander Joint Task Force (CJTF) to train their respective staffs, assess the readiness of assigned forces from both active and reserve components stationed in CONUS and deployed abroad, and evaluate possible courses of action (COAs). The ability of the defense industrial base to mobilize production of large weapon systems and platforms is essential for the readiness of the mobilized force and to support the wartime replacement of these systems and platforms.

2. Real-Time Focused Logistics

In addition to being able to rapidly project overwhelming combat power on short notice and the need to be prepared to operate as a component of a joint, combined, or multinational force anywhere in the world, it is equally essential to ensure the capability to sustain the fighting forces with the proper support forces, equipment, supplies, and services delivered to the right place at the right time. To do this, it is necessary to improve our ability to know in real or near-real time the location and status of each unit, person, piece of equipment, and item of supply, including those being held in commercial inventories. This requires improved, large-scale accounting for inventory; status monitors on people, equipment, and cargo shipments; and near-real-time access to the massive information data networks to support deployment- and sustainment-related decision making.

To ensure success in future operations, operators (J3/G3/S3), logisticians (J4/G4/S4), and planners (J5/G5) at all organizational echelons must be linked to ensure all have the same common operational picture, can coordinate their activities across organizational boundaries, and readily know the impact of their plans, actions, and decisions across the entire operational spectrum. This tightly knit environment will enable the impact of logistics to bear directly on the decision-making process during course-of-action development and execution. The key element of this coordinated process will be the ability to plan in sufficient detail to allow execution directly from the plan. The operations plan and the logistics plan are thus developed in consonance with explicit common assumptions and expectations. Deviations from the plan can be detected through the creation of trigger processes or plan sentinels placed at key nodes or links in the logistics pipeline. These plan sentinels provide the necessary closed-loop feedback to maintain control and support the oversight process. To ensure that all this can be accomplished, interoperable processing, the sharing of high quality data, and assured robust communications capability are essential.

In addition to seamless interoperability, logistics requires that information processing and communication technologies be applied to the monitoring, planning, execution, and tracking of forces and sustainment ranging from acquisition, storage, maintenance, and repair, through the entire transportation pipeline to the field. This requirement is critical to prolong the life of equipment and facilities used to support deployment and sustainment operations. Areas to be addressed include strengthening the loadbearing capacity of materials used to construct airfield pavements to accommodate aircraft with much heavier wheel loads; reducing the impact of the environment and extreme weather conditions on the infrastructure, facilities, personnel, and equipment; and mitigating the effects of high sea states that reduce the effectiveness and efficiency of discharging cargo, equipment, and bulk fuels over bare beaches and unimproved port facilities; and providing pinpoint forward resupply through precision airdrop. Reducing the logistics burden by increasing the useful life of equipment, reducing life-cycle costs, or reducing the footprint of forces necessary to support the warfighting force is also critical to realizing Focused Logistics.

Health service support imposes certain medically unique requirements above and beyond those described above to reduce the impact of personnel casualties through casualty prevention, medical support, and rapid evacuation. The medical component of focused logistics requires the capability to acquire a full spectrum of clinical and physiological information on individuals, coupled with knowledge of their location and operational environment; to dynamically access, integrate, and process data from diverse sources; to automatically interpret complex physiological and medical data patterns to determine individual performance degradation and health status; to direct and tailor the presentation of information to accelerate and simplify the cognitive understanding of integrated information; to rapidly diagnose and treat casualties at the site of injury, during evacuation, and at all deployed medical treatment facilities; and to dynamically synchronize medical resources in both the theater of operations and the CONUS sustainment base. These capabilities are required to minimize personnel casualties and save lives with minimal medical personnel and logistics tails. Individual health status monitors; physiological sensor fusion, image analysis, and diagnostic/prognostic algorithms; improved medical situational awareness interfaces; and small, deployable medical imaging systems, together with the ability to access and transmit medical data in real time and near-real time, are needed to enable these capabilities.

Capabilities are also required for improved predeployment training of medical personnel, and for enhanced medical readiness of deployed forces. These include the ability to increase individual and unit-related skills of medical personnel through realistic rehearsal of trauma care procedures and home station joint medical task force mission rehearsal for distributed forces; and the ability to provide near-real-time information on individual and unit medical readiness of the joint task force prior to deployment, to proactively project health parameters and appropriate predeployment medical interventions for joint forces, and to forecast the near-, mid-, and long-term medical impacts of operational and resource decisions on the health status of the joint force.

3. Sustainment of Strategic Systems

The Department of Defense will retain some strategic systems for an extended period of time, well beyond the originally programmed service lives of these systems. These systems contain unique, costly components. In some cases, these components are no longer available. One priority is to reduce the number of unique components. A second thrust is to reduce costs.

Sustainment of existing systems is the first operational capability element (OCE). This will be accomplished by developing more readily available process and product technologies for replacement components and survivability validation. Life monitoring and prediction techniques will also be improved.

Sustainment of the capability to design, develop, and produce strategic systems is a second OCE. New and improved modeling and simulation tools can augment diminished expertise in design, testing, and production of strategic systems. Multi-use technology, applicable to both strategic and other systems (e.g., space launch vehicles, transport and fighter aircraft), and cost-effective use of dual-use technology (involving civil sector technologies) can also contribute to the capability to design, develop, and produce strategic systems.

The third OCE is the reduction of O&M costs for existing systems. This can be accomplished through the development of technologies that will result in lower cost replacement components, ideally with longer service lives than the original parts. This includes design and development

directed at ensuring that replacement parts provide required levels of survivability and that survivability can be affordably and effectively validated. Additionally, techniques that will extend the service life of systems and their components in ways that do not compromise mission capability can reduce costs.

Advancement of strategic system capabilities is the fourth OCE. Sooner or later, just replacing components or building like systems will not be enough. Changes in operational, safety, or other requirements will necessitate investment in science and technology for higher performance, more affordable systems.

C. FUNCTIONAL CAPABILITIES

This section identifies and describes the functional capabilities that collectively enable the required operational capabilities.

1. Joint Readiness

As shown in Figure IX–1, enhanced Joint Readiness operational capability elements are impacted by (1) CINC/CJTF/battle staff training, combined staff training, and interoperability of forces and equipment; (2) individual/crew/unit planning and rehearsal of missions, and COA development; (3) status reporting, assessments, and force tailoring; and (4) industrial readiness. The functional capabilities needed to enhance the operational capability elements for Joint Readiness are shown in Table IX–1.

Table IX–1. Functional Capabilities Needed—Joint Readiness

	Operational Capability Elements							
	Train			Plan		Assess		Ready
Functional Capabilities	Joint	Combined	Interoperability	Mission Planning	Mission Rehearsal	Status Reporting	Predictive Assessment	Industrial Readiness
1. Joint/Combined Interoperability	●	●	●	●	○	●	●	
2. Combined Staff Training		●	●					
3. CINC/CJTF/Battle Staff Training	●	○						
4. Individual/Crew/Unit Planning and Rehearsal	○	○	○	●	●			
5. Collaborative Planning and Rehearsal	○		○	●	●			
6. Course-of-Action (Staff) Development	○		○	●			○	
7. Status Reports						●	○	
8. In-Theater Assessments						○	●	
9. Force Tailoring				○		○	●	
10. Industrial Mobilization								●

● Strong Support ○ Moderate Support

2. Real-Time Focused Logistics

The functional capabilities needed to enhance the stated operational capability elements to realize Real-Time Focused Logistics are shown in Table IX–2. The most important functional requirements needing enhancement are as follows:

- The ability to automatically generate logistics plans from notional to refined levels of item description, synchronize operations and logistics COA development, and monitor execution so that plan deviations can be detected and required replanning accomplished rapidly. This requires the close linkage of operations and logistics planning, execution monitoring, and dynamic replanning in a highly automated environment.

Table IX–2. Functional Capabilities Needed—Real-Time Focused Logistics

	Operational Capability Elements									
	Medical Readiness	Effective Employment			Logistics Awareness			The Grid		
Functional Capabilities	Medical Skills Proficiency and Information Superiority	Predictive Planning and Preemption	Integrated Logistics Management	Execution of Time-Critical Missions	Personnel Health and Performance Monitoring	Total Personnel and Asset Visibility	Consistent Understanding of Logistics Operations	Universal Transaction Services	Distributed Communications Environment	Assured Communications Services
1. Quality and Timely Data		●	●	●		●	●	●	○	●
2. Visibility Into the Logistics Pipeline		●	●	●		●	●	○	○	○
3. Logistics Implications of Operations		●	●	●		●	●			
4. Real-Time Logistics/Operations C^3I		●	●	●		●	●	●	○	●
5. Strategic Assessment of Supply Requirements		●	●	●		●	●	○		○
6. Logistics Requirements Generation		●	●	●		●	●			●
7. Critical-Item Identification		●	●	●		●	●	○		○
8. Course-of-Action Logistics Evaluations		●	●	●			●		●	○
9. Carrier/Load/Route Allocation		●	○	●		○	○		●	○
10. Optimal Scheduling		●	○	●		○	○		●	○
11. Plan Deviation Detection		○	○	○		○	○			
12. Adaptive Replanning and Rescheduling		●	○	●			○		○	
13. Deviation Mitigation and Cargo Offloading		○	○	●		○	○			
14. Support Force Sourcing		○	○	●		○	○			○
15. Rapid Supply Source Identification (Military and Commercial)		○	○	●		○	○	○	○	
16. Flexible Item Descriptions		○	○	●		○	○	●		
17. Expedited Procurement		○	○	●			○	●		●

● Strong Support ○ Moderate Support

Table IX–2. Functional Capabilities Needed—Real-Time Focused Logistics (continued)

	Operational Capability Elements									
	Medical Readiness	Effective Employment			Logistics Awareness			The Grid		
Functional Capabilities	Medical Skills Proficiency and Information Superiority	Predictive Planning and Preemption	Integrated Logistics Management	Execution of Time-Critical Missions	Personnel Health and Performance Monitoring	Total Personnel and Asset Visibility	Consistent Understanding of Logistics Operations	Universal Transaction Services	Distributed Communications Environment	Assured Communications Services
18. Cost/Quality Evaluations		●	○	●			○			
19. Rehearsal/Training Simulation		○	●	●			○	●		●
20. Reduced Burden of Logistics Infrastructure		○	●	○		○	○			
21. Medical Simulation	●			○						
22. Medical Readiness Assessment, Reporting, and Preventive Intervention	●									
23. Individual Status Monitoring and Assessment				●	●	●				
24. Medical Data Storage, Filtering, and Transmission				○	●	●		○		○
25. Advanced Medical Displays and Controls				●	○	○				
26. Multimedia-Supported Telepresence				●						
27. Precision Forward Resupply				●						
28. Computer-Aided Diagnosis, Treatment, and Patient Regulation				●		●				
29. Digital Medical Imaging				●						
30. Computer-Assisted Medical Force Tailoring				●		●				

● Strong Support ○ Moderate Support

- The ability of logisticians at all echelons to rapidly assess the logistics situation by converting logistics data into information-rich visualizations to understand the current situation and project future states. This requires visibility into the logistics pipeline so that decision makers and supporting staff can have a common operating picture; determine the status of personnel, equipment, units, and force packages and their capabilities, supplies, and inventories at any stage within the process; assess the timed availability of the resources; generate logistics requirements; identify critical items; and accomplish predictive force tailoring.

- The ability to maintain end-to-end control of the transportation-sustainment pipeline through the automated development of responsive transportation plans and continuous monitoring techniques. This requires near-real-time, seamless access to quality data for use in selecting modes of transportation, scheduling transportation assets, determining routes, and optimizing loads.

- The ability to maintain interoperable connectivity and access to DoD and commercial vendors, suppliers, and manufacturers in order to acquire, source, and order necessary sustainment supplies and equipment. This will increase materiel readiness, decrease cycle times, satisfy materiel requirements, and reduce DoD-held inventory and overhead costs.
- The ability to automatically capture critical elements of data, graphically represent that data as meaningful information that decision makers and support staff can easily interpret and use, and share and distribute data and information across the entire operational spectrum to provide a fused, common operating picture. This requires an assured, robust communications "grid" that will permit large volumes of data to be passed in near-real time.
- The ability to define and project the operational and health status of individual combatants prior to deployment and during military operations, provide casualty avoidance and near-real-time casualty detection and location, and provide time-integrated tracking of individual geospatial locations and quantitation of exposure to environmental hazards (e.g., biological toxins, chemical warfare agents, environmental chemicals). This requires the abilities to acquire, fuse, interpret, and use physiological, environmental, and geolocation data at an individual level.
- The ability to process and integrate multisource medical data inputs to provide clinical decision support; recommend diagnoses and therapeutic options; project patient status; implement appropriate medical interventions through interfaces with therapeutic medical devices in operator-controlled, semiautonomous, or autonomous modes; and improve timely casualty response and evacuation through increased awareness of the status of patients and medical forces throughout the evacuation chain.
- The ability to rehearse realistic combat casualty care procedures and ensure the skill proficiency and currency of first responders (combat lifesavers, combat medics, independent duty corpsmen, and physician assistants) and combat surgeons, and the ability to collaboratively plan and rehearse unit level, joint task force medical missions from home station. These require the ability to simulate medical and surgical scenarios and health service support missions with high fidelity and interactivity.

3. Sustainment of Strategic Systems

Operational capability elements for the sustainment of strategic systems are made possible by the functional capabilities shown in Table IX–3. The first functional capability is monitoring age degradation. This includes technologies for monitoring changes due to chemical aging, corrosion, and fatigue, as well as technologies that determine effects of these changes on performance, survivability, and safety, both presently and in the future. The second functional capability addresses those technologies needed to maintain the capabilities of strategic missiles, both ICBMs and SLBMs. These include the propellant and associated components (case, nozzle, etc.) for solid stages and both solid and liquid post-boost vehicles; components of reentry vehicles (nosetip, shell, base, radar window) and those portions of the post-boost vehicle associated with reentry vehicle mounting and release; and activities to study and predict the structural and dynamic responses of missiles through powered flight.

**Table IX–3. Functional Capabilities Needed—
Sustainment of Strategic Systems**

Functional Capabilities	Operational Capability Elements: Sustain Existing Systems	Sustain Capability To Design, Develop, and Produce	Reduce O&M Costs	Advance System Capabilities
1. Age Degradation Monitoring	●		●	○
2. Strategic Missile Mission Capability	●	●	●	●
3. Strategic Air-Breathing System Mission Capability	●	●	●	●
4. Strategic Submarine (SSBN) Mission Capability	●	●	●	●
5. Nuclear Survivability and Sustainment	●	●	●	●

● Strong Support ○ Moderate Support

Technologies associated with strategic air-breathing systems include those associated with aircraft and cruise missile engines, navigational systems, flight controls, avionics, and airframes. Strategic submarine technologies address submarine and SLBM functions that control the underwater launch of SLBMs through first-stage ignition in air, and submarine navigation. Nuclear survivability ensures that systems can withstand threat environments; particular, but not exclusive, emphasis is given to nuclear effects threats. Nuclear sustainment involves collaboration by DoD and DOE to ensure the long-term effectiveness and survivability of strategic systems.

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

This section identifies the functional capabilities, current limitations, underlying technology barriers, and technology solutions required to achieve each JWCO.

1. Joint Readiness

The performance goals within each functional capability, current limitations to achieving these goals, and the technologies required to overcome these limitations are identified for Joint Readiness in Table IX–4. In-theater readiness assessment and status reporting is currently limited to manual recording, relatively simple mathematical formulations, and educated estimates. The Status of Resources and Training System (SORTS) provides an estimate of current unit or force readiness based on a compilation of readiness evaluations from its component units. There is no effective predictive means for determining future personnel, equipment, or unit readiness based on ongoing operations and resourcing decisions. For example, if a unit is supporting a peacekeeping mission and not training to conduct sustained combat operations, it is difficult for a CINC to estimate with any reliability what the unit's proficiency would be to accomplish its wartime mission if it had to respond to a major regional conflict (MRC) at some future date. Advances in performance assessment methods and the development of predictive tools will lead to more robust and objective assessments of readiness from individual units to joint force levels. Additional work is needed in providing performance feedback to trainers and trainees and in aggregating and synthesizing readiness data for high-level reporting needs.

Table IX–4. Goals, Limitations, and Technologies—Joint Readiness

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Joint, Combined, and Interoperability Training			
Provide home station, real-world equipment training for distributed forces (active and reserve). Ensure cross-simulation validity of representation and interactions.	Joint/combined/interoperability Combined staff training CINC/CJTF/battle staff training	Limited interoperability of simulations at different levels of resolution Incompatible protocols and interfaces between and among deployment, redeployment, personnel, logistics, C^4I, M&S, information, and instrumentation systems Incompatible data formats for automated data processing Lack of interactive dynamic environmental effects models Bandwidth limitations of present communications nets (limited support for large block data transfers or simultaneous flow of data, voice, graphics, and video) Inability of multilevel security to interactively support a mix of classified and unclassified information Long lead time for development of environmental databases Lack of cross platform commonality of terrain databases	Easily deployable, evolvable, scaleable, interoperable, plug and play architecture for C^4, intelligence, and M&S systems for "train as we fight" capability Virtually resident database capable of self-update and automatic reconstruction and redistribution Advanced M&S tools Multilevel security Secure, high-rate, high-bandwidth communications Information fusion Tailored, natural language, information search and retrieval capability Embedded, deployable, distributed fault-tolerant M&S for mission planning, rehearsal, and training Distributed, synchronized databases Object-oriented, distributed, automated, dynamic scenario generation and exercise planning
Operational Capability Element: Mission Planning and Rehearsal			
Provide rapid response to planning and rehearsal requirements for contingency operations. Real-time mission planning. Dynamic mission retasking.	Individual/crew planning and rehearsal Collaborative planning and rehearsal Course-of-action development	Limited interoperability of simulations at different levels of resolution Incompatible protocols and interfaces between and among deployment, redeployment, personnel, logistics, C^4I, M&S, information, and instrumentation systems Incompatible data formats for automated data processing Lack of interactive dynamic environmental effects models Bandwidth limitations of present communications nets (limited support for large block data transfers or simultaneous flow of data, voice, graphics, and video) Inability of multilevel security to interactively support a mix of classified and unclassified information Long lead time for development of environmental databases Lack of cross platform commonality of terrain databases	Easily deployable, evolvable, scaleable, interoperable, plug and play architecture for C^4, intelligence, and M&S systems for "train as we fight" capability Virtually resident database capable of self-update and automatic reconstruction and redistribution Advanced M&S tools Multilevel security Secure, high-rate, high-bandwidth communications Information fusion Tailored, natural language, information search and retrieval capability Embedded, deployable, distributed fault-tolerant M&S for mission planning, rehearsal, and training Distributed, synchronized databases Object-oriented, distributed, automated, dynamic scenario generation and exercise planning Advanced collaboration planning capability

Table IX–4. Goals, Limitations, and Technologies—Joint Readiness (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Assessment and Status Reporting			
Provide near-real-time information on unit readiness; for example, relevant details on each person (education, training, health, etc.) and equipment (numbers, condition, status) for assigned forces. Tailor force packages based on near-real-time readiness status update to modify or reconfigure forces due to changes in situation, mission, or combat capability. Provide the capability to predict near- and mid-term impacts of operational and resource decisions on unit and joint readiness.	Status reporting Force tailoring Predictive assessment	Limited interoperability of simulations at different levels of resolution Incompatible protocols and interfaces between and among deployment, redeployment, personnel, logistics, C^4I, M&S, information, and instrumentation systems Incompatible data formats for automated data processing Lack of interactive dynamic environmental effects models Delay in data reporting. No common metrics for operational picture/readiness reporting, especially coalition readiness Lack of accredited algorithms to forecast readiness impacts Lack of performance measures embedded in models and simulations Lack of tools to assess collective and joint readiness and provide feedback to trainers, trainees, and commanders Lack of tools and capabilities to synthesize and report readiness	Advanced M&S tools Secure, high-rate, high-bandwidth communications Information fusion Intelligent agents to retrieve, filter, sterilize, sanitize, and deconflict information and data Object-oriented, distributed, automated, dynamic planning tools Effective methods for embedding performance measures in M&S systems Capabilities to synthesize and report readiness data After-action review tools Unit performance measures in readiness reporting
Operational Capability Element: Industrial Readiness			
Support the future readiness of naval forces by preserving the shipbuilding industrial base during the current and projected downturn in military ship construction. Support international competitive ship designs, process rationalization, and development and implementation of advanced shipyard management, ship design, and ship construction technologies.	Competitive commercial practices that can be applied for more efficient and affordable Navy ship construction in the future Maintenance of the shipbuilding industrial base to be available in time of heightened need for naval vessels	Cultural difficulties that occur within a traditionally insular industry Lack of use of advanced information technologies in the industry	Information technologies, especially simulation-based design tools, for concept formulation and marketing, detailed design and construction, and life-cycle support National shipbuilding electronic information infrastructure linking shipyards, suppliers, financiers, customers, and regulatory bodies

Collaborative mission planning is currently limited to the passing of independently generated portions of mission plans from one service or unit to another. No real-time collaborative planning tools are currently fielded that enable disparate mission planning systems to share information. Mission rehearsal tools are limited to selected weapon systems, mission preview systems, and simulators—virtually all of which are in the aviation community. Realism, or human immersion, in the simulators is limited by the lack of authoritative representations of other systems, human and group

behaviors, and the natural environment. Deficiencies and barriers to mission planning and mission rehearsal include disparate architectures among current planning systems, thus precluding interoperability; a lack of shared standards and protocols; and nonstandard databases.

The capability to conduct distributed joint, combined, and interoperability training is currently limited. Most often, live simulator-supported exercises are conducted at single locations. Not only does this involve high travel costs, but the simulation itself is most often limited to the use of artificial systems rather than real-world C^4I and weapon systems and controls. Today's computer simulations are often time and labor intensive to plan, set up, and run, and frequently require large support staffs. The principal barriers to more effective joint and combined staff training include the lack of interoperability among service and allied training simulations and models and the lack of tools and methods for assessment and feedback. Another barrier is the absence of an embedded training capability in C^4I and weapon systems. A common technical framework for modeling and simulation—based on a high-level architecture, data standardization, and a common understanding of actions and interactions—will help overcome the interoperability shortfalls and allow for a seamless, distributed simulation. Planning for interoperating with simulations from the requirements definition stage of new weapons and C^4I systems acquisition will allow for more realistic training.

The capability to maintain a highly responsive industrial base is severely limited by the current and projected downturn of military procurement. Closed production lines will not have the long-lead time and resources needed to open the facilities, retool the equipment, and hire personnel. More use of distributed, collaborative design; advanced information technologies; and leveraging of commercial efforts is needed to support industrial mobilization.

2. Real-Time Focused Logistics

The performance goals within each functional capability, current limitations to achieving these goals, and the technologies required to overcome these limitations for Real-Time Focused Logistics are identified in Table IX–5. This section summarizes the most significant initiatives underway.

Visibility over assets and resources has continued to be a very high priority. To accurately assess or determine future readiness posture, it is also important to consider our capability to sustain the force and to maintain visibility across the entire logistics pipeline and across all logistics functional areas (maintenance, supply, services, medical, personnel, engineering, etc.). Logistics processes and supporting systems are compartmentalized by functional disciplines with little or no data sharing capability. Efforts are underway in the Joint Total Asset Visibility (JTAV) program, under the sponsorship of the Deputy Undersecretary of Defense for Logistics, to link these numerous stovepipe logistics asset databases. Improvements are needed in source data capture to provide accurate and timely logistics, operations, and infrastructure data. Support of an assured advanced communications grid is also required to transfer these data along the entire logistics pipeline from point of origin to ultimate destination. Combining these data with advanced methods to monitor operations and logistics execution will provide the capability to manage sustainment across the entire spectrum of the acquisition and distribution pipeline—from "factory to foxhole." Additionally, DARPA's Advanced Logistics Program (DTO IS.46.01)—together with the U.S. Transportation Command's Global Transportation Network (GTN), JTAV, and the Transportation Coordinators' Automated Information Management System II (TC AIMS II) initiatives—is taking the critical first

Table IX–5. Goals, Limitations, and Technologies—Real-Time Focused Logistics

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Medical Readiness			
Develop training systems for medical personnel that provide realistic rehearsal of emergency medical and surgical procedures and unit-level medical operations. Provide systems to retrieve, filter, and deconflict medical information contained in computerized medical records in large, distributed medical databases. Apply artificial intelligence-based analytical capabilities to proactively project health parameters and appropriate medical interventions for joint forces prior to deployment.	Medical simulation Computer-aided medical readiness assessment, reporting, and preventive intervention	Inadequate organ, limb, and whole body surgical simulation Lack of surgical simulations with capabilities to simultaneously represent the anatomic and physiological consequences of surgical interventions Limited capabilities for haptic feedback-supported medical virtual reality systems Lack of medical unit-level mission planning and execution simulation systems Inadequate joint service simulation capabilities Inadequate interoperability among service medical modeling capabilities Bandwidth limitations to support distributed simulations Lack of real-time, comprehensive, and interactive COA joint service medical planning systems Lack of computerized patient records Lack of distributed, synchronized patient data repositories Lack of environmental and human systems models Lack of medical assessment and readiness algorithms Inability to comprehensively search and retrieve medical data from diverse sources	3D medical image processing and display systems Soft tissue and functional modeling that integrates physiological and anatomic data into coherent surgical simulation Adaptive computer-aided instruction Integrated medical imaging, computer graphics, biomechanical analysis, and virtual reality for medical education, scientific analysis, and pretreatment planning Haptic devices with tactile sensing, force amplification, and control systems with adequate latency, fidelity, and degrees of freedom Advanced medical modeling and simulation systems Medical tactical geospatial and medical information fusion systems Tailored, natural language information search and retrieval systems Object-oriented, distributed, automated dynamic scenario generation and exercise planning software Easily evolvable, scalable, interoperable, plug and play unit-level medical modeling and simulation systems Environmental effects and human systems performance modeling Intelligent agents for search and retrieval of medical data Artificial intelligence-supported medical data mining Individual and aggregate predictive diagnostics
Operational Capability Element: Effective Employment			
Collaboratively develop executable logistics plans at item-level detail, which can be globally or locally optimized through the use of COA evaluations. Reduce the planning cycle from days to hours.	Quality and timely data Visibility in to the logistics pipeline Logistics implications of operations Real-time logistics/operations C^3I Strategic assessment of supply requirements Logistics requirements generation Critical-item identification	No infrastructure investments/alternative planning Planning systems only run with summary-level data No aggregation and deaggregation processing available Logistics and transportation systems not linked to conduct movement feasibility in the "sourcing" process No cost evaluation done No automated access into logistics databases by intelligent software agents	Semiautonomous search and retrieval EDI extensions Advanced optimization Active databases and data mining Shared ontology Interoperable modeling High-fidelity simulations Adaptive workflow Intelligent agent mediator processing Advanced human/computer interface

Table IX–5. Goals, Limitations, and Technologies—Real-Time Focused Logistics (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Effective Employment (continued)			
Develop integrated logistics management systems that train joint/combined staff interoperatively using advanced rehearsal simulations to spur rapid awareness of and reaction to deviations to ensure supply. Reduce the reaction time for deviation from days to hours and in some cases minutes. Create automated execution systems to track sourcing options, expedite negotiation and ordering within realistic cost/quality criteria, optimize allocation and scheduling, and react to deviations within minutes. Improve the life expectancy and lower the cost of the infrastructure needed to move and store forces and supplies under the wide variety of local environments anticipated. Improve the capabilities of medical personnel to effectively and efficiently diagnose and treat casualties, even in mass casualty situations, with minimal manpower, at forward echelons of care and during patient transport. Optimize the use of medical resources by improving the efficiency of patient regulating and medical force reallocation to accommodate shifting patient workloads and support needs.	COA logistics evaluations Carrier/load/route allocation Optimal scheduling Plan deviation detection Adaptive planning and rescheduling Deviation mitigation and cargo offloading Support force sourcing Rapid supply source identification (military and commercial) Flexible item descriptions Expedited procurement Cost/quality evaluations Distributed rehearsal/training simulations Reduced burden of logistics infrastructure Multimedia-supported medical telepresence Computer-assisted diagnosis, treatment, and patient regulation Digital medical imaging Computer-assisted medical force tailoring Pinpointing of forward resupply locations	Limited movement optimization or scheduling within same platform Limited collaboration tools No mapping tools to assess infrastructure in theater Details for execution not linked to the plan Deviation detection during execution not possible No optimization process in use for asset allocation and scheduling No access to commercial databases Requires "pushed" data Semantics difficulties No visible requisition process—no receipt to fill No autonomous negotiation and purchase No rapid replanning capability No method to initiate replanning and rescheduling based on input from monitoring and deviation detection sentinels No method to replan with optimization to fix local or global problems Limited collaboration tools Labor-intensive and reactive critical care Inability to predict transition of stabilized patients to unstable status Medical diagnostic systems not integrated with available and emerging tactical computing/communicating capabilities Lack of forward imaging and image analysis capability for diagnosis and presurgical planning Limited communications and data sharing capabilities for real-time teleconsultation Lack of defined technical requirements for remote, robotically operated endoscopic surgical systems Limited functionality of remote, robotically operated surgical systems Force allocation decision making based on incomplete knowledge of nature of casualties Inability to rapidly analyze alternative COA Costly, vulnerable, and inaccurate airdrops	Desktop videoteleconferencing Shared whiteboards Advanced scheduling technology Motion mitigation control research Automated identification technology Object-oriented plan representation Predictive diagnostics for computer-assisted critical care and medical decision support Computer-assisted medical device control Small, noninvasive sensors for vital signs monitoring Far-forward digital image acquisition devices Computer-assisted medical image analysis and reconstruction Virtual endoscopy and other computer-assisted presurgical planning tools Real-time tracking of relevant data among joint service medical units Advanced medical robots with improved control and functionality for telepresence surgery Haptic devices with tactile sensing, force amplification, and control systems with adequate latency, fidelity, and degrees of freedom Real-time reporting of diagnostic findings Integration of patient status information with medical assets and logistics information systems Medical unit simulation and dynamic scenario generation Methods to decelerate the descent of payloads dropped from high altitudes

Table IX–5. Goals, Limitations, and Technologies—Real-Time Focused Logistics (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Logistics and Personnel Awareness			
Provide real-time visibility of the total logistics inventory from production to storage to transfer to in-field positioning in terms of numbers, readiness, and sustainability. Provide man-friendly access for every active and proposed area of operation. Provide near-real-time awareness of the operational capability of deployed units based on individual health status, identify and prevent impending casualties caused by environmental stressors, quantitate individual exposure to health hazards, and provide real-time detection of casualty events and casualty location.	Quality and timely data Visibility into logistics pipeline Real-time logistics and operations C^3I Strategic assessment of supply requirements Logistics requirements generation Critical-item identification Plan deviation detection Distributed rehearsal and training simulations Reduced burden of logistics infrastructure Individual status monitoring and assessment Medical data storage, filtering, and transmission Advanced medical displays and controls	Human Interaction with creating source data. No automated source data capture No real-time feedback on the status of logistics operations Only nodal reporting within ITV process No infrastructure capability feedback No automated source data capture No real-time monitoring feedback from transportation movements, and operational status of infrastructure that supports logistics framework No logistics visualization techniques No method to detect deviations that occur and signal the need for replanning No mapping tools to assess infrastructure in theater Inability to remotely and nonintrusively measure health parameters under field conditions Inability to identify or quantitate individual exposure history to environmental hazards, biological/chemical threat agents, and other stressors during deployment Lack of joint-service medical situational awareness software system Lack of an integration platform for physiological status monitor and LSTAT output and display Lack of physiological models to assess and predict health status of individuals Lack of integrated data on such factors as impact of sleep loss, energy expenditure, environmental stress, and performance impairment that signal impending casualty status Bandwidth limitations on transfer of medical data Logistic insupportability of systems necessary to display medical data and images to far-forward health care providers Limited capability to provide medical commanders with integrated picture of medical forces and status of individuals Inability of users to rapidly access information needed to optimize efficiency of medical decision making	Deviation detection from monitoring systems In-theater measurements monitors Infrastructure monitors Dependency-driven notification of deviation from plan Next-generation AIT research Embedded software agents ("sentinels") Noninvasive biochemical and biophysical sensors (sonographic, infrared, and other) Sensor and signal-coupling technologies to enable time-integrated quantitation of exposure to biological toxins, chemical warfare agents, and selected environmental hazards Integration of health status sensor systems with other sensor and individual computer systems Object-oriented, medical situational awareness system that is joint-service interoperable Interfaces between medical situational awareness system and status monitors and trauma transport systems Ability to process aggregate biotelemetry and fuse it with environmental effects models for human system prognostics and operational decision making Functional-biological modeling for remote impairment prediction and injury detection Individual data logging for store and forward use 3D medical image processing Multimedia transmittable, transportable repository systems Dynamic, interactive graphical medical-tactical geospatial displays Flat-panel medical displays Laser retina, hands-free, heads-up displays Medical speech recognition Information on cognitive processing of medical information Artificial intelligence-based medical information management

Table IX–5. Goals, Limitations, and Technologies—Real-Time Focused Logistics (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: The Grid			
Tie the logistics system to the Universal Transaction Services so that all force and supply sourcing, carrier, route, storage, and in-field positioning options are available in real time for rapid planning and execution.	Quality and timely data Real-time logistics and operations C^3I Carrier/load/route allocation Optimal scheduling Expedited procurement Distributed rehearsal/training simulations	No automated access into logistics databases by intelligent software agents Deviation detection during execution not possible No access to commercial databases No real-time feedback on status of logistics operations No infrastructure capability feedback No automated source data capture No real-time monitoring feedback from transportation movements, and operational status of infrastructure that supports logistics framework No method to automatically notify all players of replan action	Covered in Information Superiority (Chapter IV)

steps in providing the needed near-real-time asset visibility and control of the overall logistics pipeline.

The Army's Total Distribution ATD developed the Logistics Anchor Desk, which provided logistics and operational planners a limited collaborative planning capability using a suite of software tools and commercial workstations. This effort was completed in April 1997. A follow-on effort is now underway to migrate a subset of this functional capability to a web-based decision support tool/GCSS environment and to develop new logistics Joint Decision Support Tools (JDSTs) that enhance logistics interoperability with operations and other functional disciplines (DTO F.19).

Logistics planning is presently only loosely coupled to operations planning. The warfighting commander delineates the overall mission and concept of operation. The operations staff (J3) outlines the alternative COAs and the requirements necessary to accomplish the mission with little input from logistics planners on their ability to support the concept of operations. The summary level of the logistics portion of the plan does not usually reflect what will eventually move. There is very little real-time feedback to commanders to tell them whether they are deviating from the plan. As unforeseen events begin to affect the actual movement, operators and planners cannot predict the magnitude of the breakdowns or their location. The planning and execution processes suffer greatly from compartmentalized systems that lack the detail necessary to make timely, accurate decisions.

It is also important to reduce the burden on the logistics systems by extending the useful life of equipment and lowering infrastructure and facility costs. The present transportation infrastructure is not a totally integrated intermodal system and reacts slowly when stressed by massive transportation movement requirements. During logistics over the shore, bare beach, or austere port operations, the transfer of cargo and fuel from sea to shore is not reliable. Wave motion compensation and near-shore soil assessment techniques are inadequate. Onsite assembly of cargo causeway systems in the high sea state conditions is unreliable and unwieldy. Continuous-flow pipelines, surface or underwater, have proven unreliable, especially across extended ship-to-shore distances, which extend up to 25 nautical miles. Given the large amount of fuel in a 25-nautical-mile pipeline, if a break occurs,

adverse environmental and operational impacts can be significant. While "batch systems" appear to have potential, more information is needed about their reliability.

The littoral environment differs enough throughout the world that fouling of facilities and operational areas has become a problem. Road, bridge, and airfield construction overseas, using local materials, is unreliable due to the often poor quality of the materials and the inability to assess the ground mobility properties of the local terrain. Wheel and tread weights of aircraft and ground vehicles continue to increase. This can result in extensive damage to critical facilities such as road surfaces, bridges, airfield runways, etc., particularly in areas with extreme climatic conditions. Methods for providing rapid design, construction, repair, and maintenance have not been put in place for the variety of environments anticipated, especially in cold areas. Portable, lightweight, self-erecting composite shelters with low signatures are needed together with lightweight power generators, heat pumps, and waste disposal systems.

Firefighting is hampered by an inadequate ability to detect fires and to see into a fire to determine problems and focus points. Firefighters are often inadequately protected from the chemicals and heat, especially where hazardous materials are involved. Many fire suppression agents are toxic and need to be replaced with new materials. Present fire-rescue vehicles are inadequate to deal with crashes involving modern aircraft and need radical improvement.

Medical aspects of joint logistics are being addressed through the development of telemedicine-related technologies. The supporting technologies for telemedicine are still in their early life cycle. Current systems are primarily limited to transmitting data from one location to another. To achieve the operational capabilities, systems will need to be powerfully augmented to process and add value to medical data.

Today's programs are just beginning to explore the full potential of integrated telemedicine applications. Most existing telemedicine programs limit their focus to one or two potential applications. Many programs just focus on video applications for remote consultation or still image transmission between sites. A few are beginning to experiment with integrated systems that combine patient point-of-care data capture, automated medical records access, and expert medical decision support systems in addition to the remote video and still-image capability.

In many cases, because telemedicine applications are relatively new, the clinical requirement and the technical requirements needed to satisfy it are not yet well understood. To the extent that military forces must operate on a hostile physical and electronic battlefield, additional technological barriers are presented to the effective utilization of these technologies. Substantial additional research and development are required to fully understand the optimal utilization of these technologies in a unique military combat environment.

Currently fielded systems do not have computerized archives of patient data or the capability to analyze these data to forecast the health of the force. There is only limited capability for medical/surgical simulation to support physician/medic trauma readiness. Moreover, standardized, realistic, joint-service surgical and unit-level simulations are not available to support improved combat trauma and mission planning and rehearsal requirements. Physiological monitoring devices and real-time prognostic artificial intelligence systems are only in the early stages of development and have not yet been developed and fielded on a wide-scale basis. There is currently no capability to comprehensively measure and assess the physiological status of operational personnel, remotely detect or predict impairment, or remotely detect and locate casualties. There is only limited

capability for en route vital signs monitoring during evacuation, and no capability to project changes in patient health status. Far-forward capability for digital image acquisition is nonexistent, and there is only limited capability for collaborative teleconsultation between echelons of care.

Technological barriers to overcoming these deficiencies in medical systems fall into five areas:

- *Human Domain*—Improved understanding of human responses to stress and trauma is needed to identify an optimal set of measurable physiological events capable of determining and predicting changes in the overall functional and medical status of an individual.
- *Sensor Systems*—Physiological signal detection and imaging technologies are needed that are appropriately sensitive and selective and can function within logistic, environmental, and other battlefield constraints. These technologies must interface with communications and information management systems.
- *Communications and Information Management Systems*—Improvements in technology are needed to provide seamless storage and transfer of physiological/medical information throughout the operational continuum, with full interoperability and ready access to all users.
- *Knowledge Integration and User Interfaces*—Technology is needed to add predictive value to physiological data through sensor fusion and to filter and present data to various users according to their needs (e.g., medics, unit commanders, physicians, patient regulators) to enable meaningful interpretation and decision support.
- *Effector Systems*—Technologies are needed to implement medical treatment decisions over long distances (e.g., through medical device control or robotics).

3. Sustainment of Strategic Systems

Major deficiencies exist in the area of sustaining existing strategic systems. Monitoring and predictive capabilities dealing with age-related problems are inadequate due to inabilities to detect hidden flaws and limited abilities to predict future problems. Sustaining existing systems becomes difficult if industry ceases to produce needed components. Reliance on unique, expensive materials and processes is risky, with the possibility of the source disappearing. Current nondestructive inspections can miss missile propellant flaws near the case wall. Predictive capabilities are limited to a 5-year horizon. Limitations exist in predicting the long-term behavior of materials and electronics in nuclear warheads. For aircraft, deficiencies exist in predicting the response of aircraft structures to corrosion, damage, or unsteady loads. In some cases, industry already has ceased to produce unique components—for example, reentry system heatshields and submarine navigation systems. The loss of underground nuclear testing poses problems for survivability validation of new replacement materials and components.

The existing capability to design, develop, and produce future strategic systems is dependent on a core of experienced personnel, adequate test facilities, and some unique materials. Retaining this capability becomes problematic when needed expertise disappears due to lack of use, test facilities are lost and existing simulators are not adequate, and unique materials become unavailable.

Addressing underwater missile launches and overall missile design depends on personnel expertise. SLBM motors, submarine navigation systems, and reentry systems all use unique materials. The loss of missile testing facilities can lead to uncertainties in mission capabilities. The loss of underground testing for nuclear effects can lead to uncertainties in the survivability of future systems.

Expensive nondestructive evaluations, costly subsystems and components, costly simulators, unique materials and approaches, and low levels of integration all lead to high O&M costs. Non-destructive techniques to monitor age degradation are time intensive, and their data evaluations are manual, expensive operations. High-cost components for submarine navigational systems and service-unique and low levels of integration for aircraft avionics are examples leading to high O&M costs. Present shortfalls in simulator capabilities and methodologies mandate expensive multiple tests to validate hardening against multiple nuclear effects. Some promising materials and electronics are more susceptible to nuclear effects, and shortfalls exist in the ability to design for affordable, effective survivability. Greater reliance is needed on advanced computations to evaluate survivability and warhead revalidation.

The final operational capability element is advancing system capabilities. Propellant performance dictates missile size and cost. Therefore, a requirement to increase range would translate to a larger missile (with today's propellants) and increased cost. Improved propellants, however, would negate the size increase and result in lower costs. Additionally, a decreasing pool of individuals with design expertise and expensive testing limit development of higher performance missiles. In aircraft, advancing system capabilities often means reducing weight, size, and power requirements, as is the case of avionics. Increased thrust-to-weight ratios are another way to improve aircraft performance.

Table IX–6 depicts operational capability elements and associated limitations for the sustainment of strategic systems.

**Table IX–6. Goals, Limitations, and Technologies—
Sustainment of Strategic Systems**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Sustain Existing Systems			
Develop more readily available process and product technology for replacement components Develop improved life monitoring and prediction techniques	Strategic ballistic missiles Strategic submarines (SSBNs) Strategic air-breathing systems Monitoring of age degradation Nuclear survivability and sustainment	Expensive unique single-source materials, some no longer made Repair lines shut down Limited predictive capabilities for material degradation due to aging Unable to detect potentially fatal flaws near missile case wall Unable to predict response of aircraft structures to corrosion, multisite damage, or unsteady aerodynamics End of underground nuclear effects testing System- and component-level validation difficult Lack of guidance for design of affordable, survivable systems Modifications and aging may impact system safety Shortfalls in simulator capability New computational capabilities needed for collaboration with DOE ASCI	Thermal/mechanical properties Missile case design Propellant chemistry Elastomeric and plastic materials Nonlinear constitutive laws Nozzle design Refractory materials Fiber-optic gyroscope and associated thermal control Accelerometer High-resolution radiography systems Defect and damage assessment Structural, ballistic, and aerodynamic response codes Structural mechanics Improvements in simulator effects fidelity and size of testable objects Integrated hardening/validation methods Design protocols for testable and affordable systems Probabilistic risk assessment Survivability assessment technology Advanced computations, computational physics, and simulators

Table IX–6. Goals, Limitations, and Technologies— Sustainment of Strategic Systems (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Sustain Capability to Design, Develop, and Produce			
Develop modeling and simulation tools Develop multi-use technology applicable to both strategic and other systems	Strategic air-breathing systems Strategic ballistic missiles Strategic submarines (SSBNs) Nuclear survivability and sustainment	Fewer personnel with design expertise and experience Testing facilities expensive or not available Class 1.1 propellants contain unique materials and are shock sensitive Shortfalls in simulator fidelity and for size of objects that can be tested End of underground nuclear effects testing Limited market for components and materials hardened to strategic standards New electronics more susceptible to EM Shortfalls in computational methods	Aerodynamics, aeroelastic phenomena, and structural dynamics and mechanics Hydrodynamic modeling and simulation Computational fluid mechanics Nonlinear stability prediction methods/codes Flight simulation techniques Missile case design Propellant chemistry Nozzle design Refractory materials Thermal/mechanical properties Advanced pulse power; advanced computational physics and methods/ modeling Survivability assessment technology Collaboration with DOE in evaluations of data, critical skills, and materials/simulator testing and modeling Improved effects simulators Test protocols and hardening technologies Radiation-hardened electronics
Operational Capability Element: Reduce O&M Costs			
Develop technology for lower cost, longer life components Develop service life extension techniques	Strategic submarines (SSBNs) Strategic air-breathing systems Strategic ballistic missiles Monitoring of age degradation Nuclear survivability and sustainment	Unique, expensive components (e.g., submarine gyroscope systems) Service unique; low level of integration in avionics leads to higher cost Limited ability to control potentially damaging dynamic loads Nondestructive techniques—time intensive Nondestructive data evaluation—a manual, expensive operation New microelectronics susceptible to EM hazards Shortfalls in ability to design for affordable, effective survivability and to evaluate component options Shortfalls in simulator fidelity Shortfalls in computational methods	Fiber-optic gyroscope Structural and material properties Integrated testbed Photonics Sensors and information fusion Aerodynamic response codes Automated nondestructive inspection methods Automated data evaluation DoD/DOE collaboration through POGs and dual revalidation surveillance, development of advanced computational physics and models, engineering and testing Improvements in simulator fidelity and size of testable objects Pulsed power and x-ray simulators Survivability assessment technologies Balanced hardening Testable hardware protocols

Table IX–6. Goals, Limitations, and Technologies— Sustainment of Strategic Systems (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Advance System Capabilities			
Develop technology for higher performance, more affordable systems	Strategic ballistic missiles Strategic air-breathing systems Strategic submarines (SSBNs) Nuclear survivability and sustainment	Propellant performance dictates missile size and cost Unable to significantly increase aircraft payload, increase mission radius, or reduce weight with current engine technology Increased reliability, reduced repair time needed to advance capabilities Current size, power requirements, and analog electronics lead to higher weight of these systems in aircraft Unable to accurately predict performance without expensive testing Survivability of promising technologies not demonstrated Shortfalls in computational methods	Missile case design Propellant chemistry Nozzle design Refractory materials Aerothermodynamic design, aeroelastic phenomena, and structural dynamics and mechanics Online aerodynamic models Photonics and electro-optics Low-power electronics Hydrodynamic modeling and simulation Test facility design Computational fluid mechanics Development/validation of enabling technology to new generation of rad-hard microelectronics Testable hardware protocols Balanced hardening DoD/DOE collaboration in use of simulators, engineering, advanced computations to evaluate options

E. TECHNOLOGY PLAN

This section describes the Joint Warfighting Experiments (JWEs), Advanced Concept Technology Demonstrations (ACTDs) and Advanced Technology Demonstrations (ATDs), and critical enabling technologies planned to overcome the identified deficiencies and barriers to provide the operational capabilities necessary for achieving each JWCO.

1. Joint Readiness

The currently programmed DTOs on the critical path to supporting joint readiness are listed in Table IX–7. An indication of the areas of operational capability most impacted by these technologies is provided in Table IX–8. Figure IX–4 illustrates how these technology developments support overall joint readiness. Note that these tables and the figure show that many DTOs from other sections are crucial to achieving joint readiness. These are primarily a series of battlefield visualization and assessment tasks in Joint Warfighting from Information Superiority (Chapter IV) and from Military Operations in Urban Terrain (Chapter VIII). Several additional tasks from Information Systems and Technology (IS&T; Chapter III of the DTAP) and Human Systems (HS; Chapter IX of the DTAP) also critically support modeling and simulation, communications, and personnel performance needs for rehearsal and training simulations.

Table IX–7. Defense Technology Objectives—Joint Readiness

DTO No.	Title
F.01	Synthetic Theater of War ACTD
F.02	Advanced Joint Planning ACTD
F.05	MARITECH
F.06	Joint Training Performance Assessment Technologies
F.10	Joint Readiness Extension to Advanced Joint Planning ACTD
F.19	Joint Logistics ACTD
A.06	Rapid Terrain Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.12	Information Dominance (C^2 Protect & Attack for I/O ATD)
E.02	Military Operations in Urban Terrain ACTD
HS.04.06	Knowledge Representation Technologies for Human Performance Enhancement
HS.08.06	Crew System Engineering Design Tools
HS.13.06	Human-Centered Automation Testbed
HS.15.06	Integrated Personnel Management Technologies
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.10.01	Simulation Interconnection
IS.11.01	Simulation Information Technologies
IS.12.01	Simulation Representation
IS.21.01	Assured Communications
IS.40.01	Individual Combatant and Small-Unit Operations Simulation

The Joint Readiness DTOs include the following:

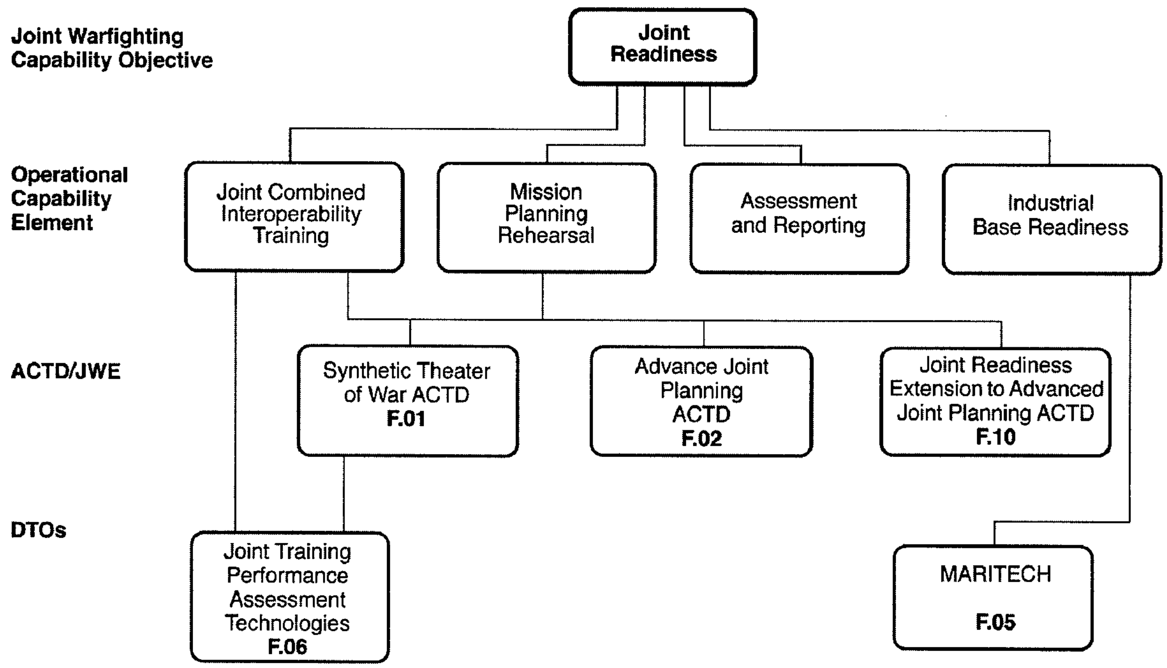
- *F.01, Synthetic Theater of War ACTD,* will improve the quality of training and assessment simulations by developing representations of combat actions resolved at the weapon system level, command and control behaviors, and high-resolution dynamic environments that include tactically significant environmental effects.
- *F.02, Advanced Joint Planning ACTD,* will provide USACOM, Joint Staff, and other CINCs an increased ability to rapidly plan, package, and deploy forces to multiple regional conflicts.
- *F.05, MARITECH,* will support the future readiness of naval forces by preserving the shipbuilding industrial base during the current and project downturn in military ship construction.
- *F.06, Joint Training Performance Assessment Technologies,* will develop and demonstrate new measurement methods to evaluate complex simulations for training and rehearsal by higher echelons and joint forces.
- *F.10, Joint Readiness Extension to Advanced Joint Planning (AJP) ACTD,* will extend the AJP ACTD to include the Automated Joint Monthly Readiness Review (AJMRR) program.

Table IX–8. Demonstration Support—Joint Readiness

Demonstration	Operational Capability Elements: Joint, Combined Training for Interoperability	Operational Capability Elements: Mission Planning and Rehearsal	Operational Capability Elements: Status Reporting and Predictive Assessment	Operational Capability Elements: Industrial Readiness	Service/ Agency	Type of Demonstration: DTO	Type of Demonstration: ACTD	Type of Demonstration: ATD
Synthetic Theater of War ACTD	●	○	●		DARPA	F.01	X	
Advanced Joint Planning ACTD	○	●	○		DARPA	F.02	X	
MARITECH			○	●	DARPA	F.05		
Joint Training Performance Assessment Technologies	●	○	○		Army	F.06		
Joint Readiness Extension to Advanced Joint Planning ACTD	●	○	●		DARPA	F.10	X	
Joint Logistics ACTD		○	●		Joint	F.19	X	
Rapid Terrain Visualization ACTD	●	●	○		Army	A.06	X	
Battlefield Awareness and Data Dissemination ACTD	●	●	●		DARPA	A.07	X	
Information Dominance (C^2 Protect & Attack for I/O ATD)			●		Army	A.12		X
Military Operations in Urban Terrain ACTD	●	●	○		Joint	E.02	X	
Knowledge Representation Technologies for Human Performance Enhancement	●				Air Force	HS.04.06		
Crew System Engineering Design Tools			○	●	Air Force	HS.08.06		
Human-Centered Automation Testbed	●	●	○		Air Force	HS.13.06		
Integrated Personnel Management Technologies			●		Army	HS.15.06		
Forecasting, Planning, and Resource Allocation	○	●	●		Joint	IS.02.01		
Simulation Interconnection	●	●		○	DMSO	IS.10.01		
Simulation Information Technologies	●	●	●	○	DMSO	IS.11.01		
Simulation Representation	●	●	●	○	DMSO	IS.12.01		
Assured Communications	○	●	●	○	Army, Air Force	IS.21.01		
Individual Combatant and Small-Unit Operations Simulation	○	●	○		Army	IS.40.01		

● Strong Support ○ Moderate Support

- *HS.04.06, Knowledge Representation Technologies for Human Performance Enhancement,* will develop a unified and comprehensive knowledge representation technology that supports the acquisition, storage, maintenance, retrieval, and application of digitally coded human knowledge and skill.
- *IS.10.01, Simulation Interconnection,* will develop a high-level architecture (HLA) and other advanced M&S technologies to connect joint and component simulations, in a composable fashion, to support the functional areas of training, mission planning/ rehearsal, acquisition, and assessment.



Supporting JWSTP DTAP DTOs

A.06	Rapid Terrain Visualization ACTD
A.07	Battlefield Awareness and Data Dissemination ACTD
A.12	Information Dominance (C^2 Protect and Attack for I/O ATD)
E.02	Military Operations in Urban Terrain ACTD
HS.04.06	Knowledge Representation Technologies for Human Performance Enhancement
HS.08.06	Crew System Engineering Design Tools
HS.13.06	Human-Centered Automation Testbed
HS.15.06	Integrated Personnel Management Technologies
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.10.01	Simulation Interconnection
IS.11.01	Simulation Information Technologies
IS.12.01	Simulation Representation
IS.21.01	Assured Communications
IS.40.01	Individual Combatant and Small-Unit Operations Simulation

Figure IX–4. Technology to Capability—Joint Readiness

- *IS.11.01, Simulation Information Technologies,* will develop conceptual models of the mission space (CMMS), authoritative data sources (ADSs), a modeling and simulation resource repository (MSRR), and verification, validation, and accreditation (VV&A) tools for developing simulations that provide consistent, reliable, and credible results.
- *IS.12.01, Simulation Representation,* will develop authoritative synthetic representations of the natural environment (terrain, oceans, and atmosphere), the performance and capabilities of warfighting systems, and human behaviors (individual and group) to enhance the realism of models and simulations in training, mission planning/rehearsal, acquisition, and assessment.

Technology advances are needed to effectively link live, virtual, and constructive simulations. The Synthetic Theater of War (STOW) ACTD (F.01) is intended to develop and demonstrate modeling and simulation technology for the next generation of training tools needed by the

Combatant Command, Commander Joint Task Force, and Joint Task Force Component Commanders and their staffs. This Joint Simulation System (JSIMS) will be the first training capability to fully utilize the data collection, assessment, management, and display technology advances envisioned in this plan. Several IS&T DTOs are on the critical path to enhance joint readiness capability. The most important are Simulation Interconnection (IS.10.01); Simulation Information Technologies (IS.11.01); Simulation Representation (IS.12.01); Forecasting, Planning, and Resource Allocation (IS.02.01); and Assured Communications (IS.21.01). In combination, these technology focuses will demonstrate the use of a common technical framework (CTF) that facilitates unprecedented interoperability among simulations and C^4I systems. The CTF framework will be used by STOW, JSIMS, Joint Warfare Simulation (JWARS), and all the other simulation developments. The collective goal of these efforts is to reduce exercise planning and setup time by 70 percent, reduce the exercise support cadre by 50 percent, and reduce travel in support of command post and computer-aided exercises by 60 percent. The DoD *Modeling and Simulation Management Plan* (Reference 18) provides a more detailed discussion of objectives in this area.

This CTF and seamless interfacing enables real-time dynamic collaborative planning using automated mission planning and rehearsal across all service and mission areas. The Advanced Joint Planning ACTD (F.02) will leverage the advances in distributed modeling and simulation to demonstrate C^4I systems integration for distributed collaborative planning capability and common perception of the battlespace. This will result in an 80 percent reduction in CINC planning cycles for emerging crisis response and a 60 percent reduction in planning time for major deployments. This aspect of joint readiness is also supported by the Joint Logistics ACTD (F.19), which is developing Joint Decision Support Tools; and the Advanced Logistics Program, which is developing the advanced software and hardware tools for logistics planning, execution, monitoring, and replanning capabilities that are to be phased into the demonstrations over time.

In addition, other IS&T DTOs support Joint Readiness. The Forecasting, Planning, and Resource Allocation DTO (IS.02.01) addresses the development of a proactive planning process to avoid direct conflict or to react quickly if conflict becomes inevitable. The Assured Communications DTO (IS.21.01) provides the secure guards and firewalls needed at the B3 level of service and develops new communication waveforms with less susceptibility to jamming. The Individual Combatant and Small-Unit Operations Simulation DTO (IS.40.01) is to develop the real-time, multisensory, virtual-reality simulation of the battlefield that puts individual combatants in three-dimensional geographic space to provide more realistic training and COA evaluations.

Information Superiority technology feeds into these demonstrations by developing specific tools for sensing in-theater forces, reporting their readiness, processing and transferring the data, fusing the information content into decision-useful displays, and assessing and planning force and mission responses. The Rapid Terrain Visualization ACTD (A.06) will merge digital imagery with terrain data to rapidly develop databases that can provide realistic depiction of areas of operation for training and real-world contingencies. These databases must be highly accurate for each specific application in terms of surface resolution, guidance precision, friend and foe signatures, etc. The IS&T DTAP DTO, Simulation Representation (IS.12.01), will demonstrate the capability to reduce the time necessary to develop terrain databases by 75 percent or more to meet the needs of the special operations community for delivery within 96 hours to support mission planning and rehearsal. The Sensors, Electronics, and Battlespace Environment DTAP DTO, Forecast of Littoral Currents and

Waves (SE.45.01), supports the objectives of the Simulations Representation DTO above, as well as exploits accurate forecasts for use in operational planning and execution.

Battlefield Awareness and Data Dissemination (BADD) ACTD (A.07) will allow commanders to design their own information systems to deliver accurate, timely, and consistent pictures of the joint/coalition battlefield. Vital to these capabilities is a marked improvement in networking, multilevel security, and communication technologies, such as those produced by the improved Information Dominance ATD (A.12) and the Assured Communications DTO (IS.21.01). Individual and small-unit performance in complex urban environments will be addressed separately in the Military Operations in Urban Terrain (MOUT) ACTD (E.02) with a goal of increasing situational awareness at all levels by 50 percent and increasing force survivability by 20 percent.

Feedback tools for training and joint force assessment methodologies will be demonstrated in the Joint Training Performance Assessment Technologies (JTR) DTO (F.06). Investments in synthetic environments and distributed simulations can be leveraged to develop new measurement methods essential for evaluating complex simulations for training and rehearsal of higher echelons and joint forces. Enhanced measurement will improve assessment capabilities and help training focus on the higher echelon tasks that need more emphasis. This effort is expected to result in 25 percent fewer errors in day-to-day training performance and a 50 percent expansion in the number of warfighting tasks measured and assessed during exercises. The most significant benefit of the MARITECH DTO (F.05) will be the maintenance of the shipbuilding industrial base to be available in time of a heightened need for naval vessels.

Figure IX–5 is the roadmap for developing and demonstrating the technologies required to support the advances in functional and operational capabilities that affect joint readiness. This roadmap shows how advances in advanced distributed simulation, communication technologies, and information management will provide significant improvements in the ability to conduct distributed joint, combined, interoperable, and staff training of various scales.

2. Real-Time Focused Logistics

The mission and supporting logistics planning must be accomplished in consonance if the overall campaign plan is to be successfully executed. It is critical to ensuring that the right capability, the right resources, and the right quantity of sustainment supplies are at the right place at the right time. Accurate and accessible information is the foundation on which the logistics systems must be built. This means automated capture of accurate data at the source; sentinels to automatically monitor the status of people, weapons, infrastructure, facilities, and sustainment supplies; autonomous connection of heterogeneous and distributed databases; semiautonomous search and retrieval; and intelligent query for information. The DTOs supporting logistics are listed in Table IX–9. Following the table is a brief summary of the most significant DTOs.

- *F.16, Logistics Technologies for Flexible Contingency Deployments and Operations,* will develop and demonstrate new technologies and methods to improve the deployment planning process to support flexible, rapid contingency deployments and predict support asset and bed-down operations requirements at austere deployed locations.

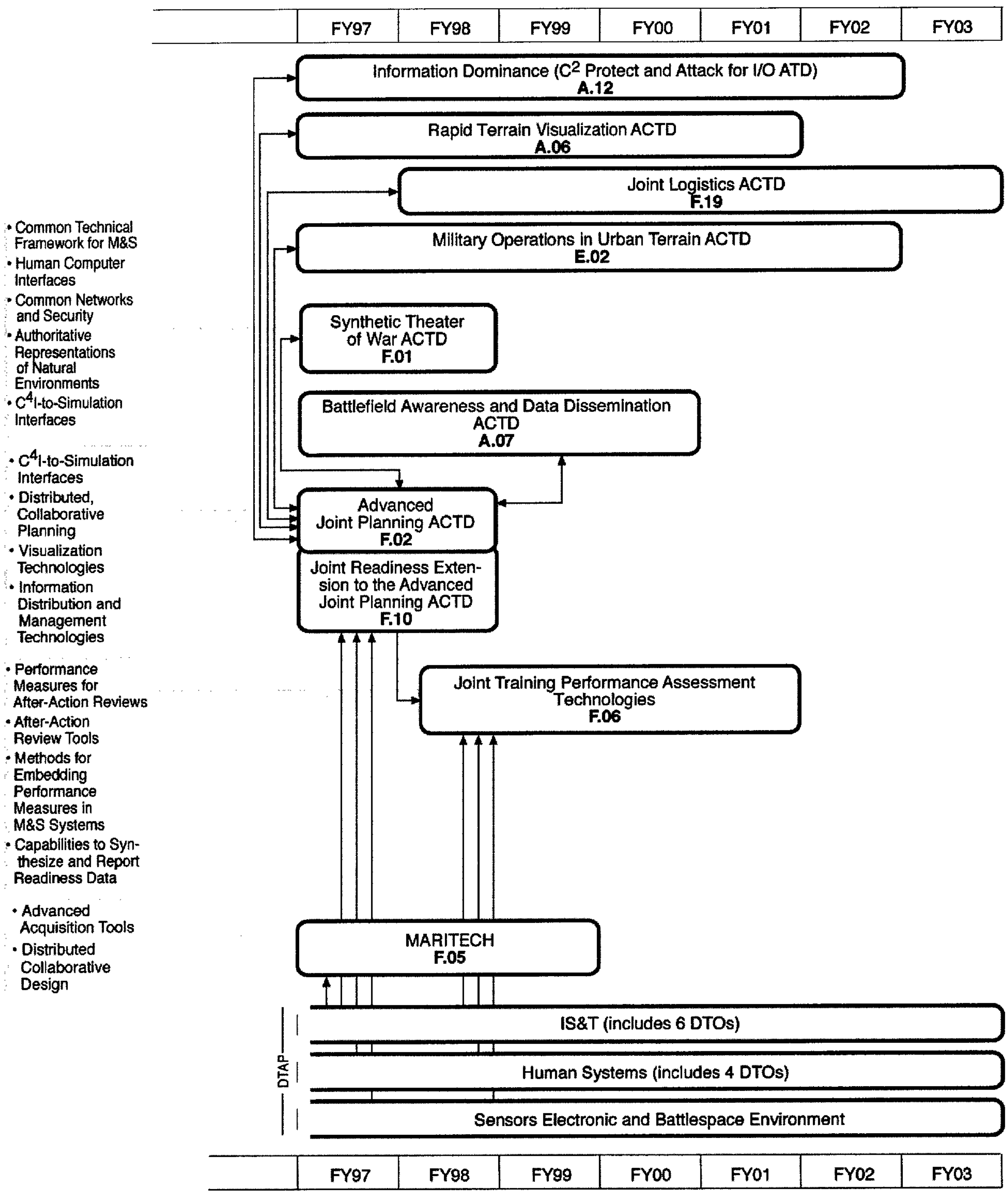


Figure IX–5. Roadmap—Joint Readiness

Table IX–9. Defense Technology Objectives—Real-Time Focused Logistics

DTO No.	Title
F.16	Logistics Technologies for Flexible Contingency Deployments and Operations
F.17	Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD
F.18	Joint Advanced Health and Usage Monitoring System ACTD
F.19	Joint Logistics ACTD
F.20	Joint Modular Lighterage System ACTD
F.22	Battery Charger/Analyzer
F.23	Modular Aircraft Support System
A.02	Robust/Tactical/Mobile Networking
A.07	Battlefield Awareness and Data Dissemination ACTD
A.12	Information Dominance (C^2 Protect & Attack for I/O ATD)
E.02	Military Operations in Urban Terrain ACTD
F.02	Advanced Joint Planning ACTD
HS.02.06	Advanced Hybrid Oxygen System
HS.06.01	Joint Cognitive Systems for Battlespace Dominance
HS.10.05	Force XXI Land Warrior
HS.12.02	Helmet-Mounted Sensory Ensemble
HS.18.02	Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel
IS.01.01	Consistent Battlespace Understanding
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.03.01	Integrated Force and Execution Management
IS.10.01	Simulation Interconnection
IS.11.01	Simulation Information Technologies
IS.15.01	Assured Distributed Environment Support
IS.20.01	Universal Transaction Communications
IS.21.01	Assured Communications
IS.23.01	Digital Warfighting Communications
IS.28.02	Intelligent Information Technology
IS.46.01	Advanced Logistics Program
MD.09.J00	Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas
MP.07.06	Affordable Sustainment of Aging Aircraft Systems
MP.12.11	Higher Sea State Logistics Support for Expeditionary Forces ATD
MP.13.11	D-Day Fuel Support for Expeditionary Forces ATD
MP.14.11	Wartime Contingencies and Bare Airbase Operations
MP.16.06	Firefighting Capabilities for the Protection of Weapon Systems
MP.17.11	Airfields and Pavements To Support Force Projection
MP.18.11	Life-Extension Capabilities for the Navy's Aging Waterfront Infrastructure ATD
MP.32.01	Fast, Affordable Product Realization
SE.35.01	Optical Processing and Memory

- *F.17, Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD*, will develop and demonstrate advanced seabase sustainment and combat service support technologies supporting emerging operational concepts. Objectives include developing new warfighter/seabase interface concepts for enhanced joint and allied force interoperability, analyzing and documenting future seabasing platform concepts to support Naval Expeditionary and Amphibious Ready Group forces, developing and demonstrating technologies to improve seabase operational efficiency, reducing manpower requirements, increasing intermodal throughput capacity, and developing and integrating common tactical logistics improvements for inter- and intra-seabase total asset visibility.
- *F.18, Joint Advanced Health and Usage Monitoring System ACTD*, will evaluate technologies focusing on reducing helicopter life-cycle costs, improving system safety and performance, increasing operational availability, and streamlining maintenance and logistics processes. Additionally, it will evaluate advanced commercial health and usage monitoring systems and assess their military utility.
- *F.19, Joint Logistics ACTD*, is a multiphase effort to develop interoperable joint logistics decision support tools and migrate existing tools to the Global Combat Support System (GCSS); make tools available to all users via a web-based client server environment that complies with Defense Information Infrastructure DII/Common Operating Environment (COE) architecture standards and requirements; make logistics interoperable with operations, intelligence, and other functional areas with the DII, the GCSS, and the Global Command and Control System (GCCS); and test maturing technologies and tools for increased operational capability. The functional capability being migrated is a subset of that initially fielded as part of the Army's Logistics Anchor Desk (LAD), which was declared "complete" in April 1997.
- *F.20, Joint Modular Lighterage System ACTD*, will build and demonstrate a joint-service, interoperable prototype causeway lighterage system capable of being safely assembled and operated, in a loaded condition, through sea state 3.
- *F.22, Battery Charger/Analyzer*, will develop and build a single-unit battery charger/analyzer system that will automatically identify, configure for analysis, perform diagnostics and maintenance on rechargeable batteries, and determine the charging state of primary batteries. This will eliminate the need for separate unique chargers for each type battery.
- *F.23, Modular Aircraft Support System*, will design, build, and demonstrate a proof-of-concept aerospace ground equipment (AGE) unit that supplies aircraft with electricity, cooling air, nitrogen, hydraulic, and related utilities from modular, multifunctional carts. This will improve supportability while reducing deployment airlift requirements, costs, and the on-the-ground logistics "footprint."
- *IS.46.01, Advanced Logistics Program*, is developing and demonstrating the feasibility of a fully automated, end-to-end logistics system to improve logistics support to the warfighter. It will develop the advanced information systems technology to gain control of the logistics pipeline; enable the warfighter to project and sustain overwhelming combat power sooner; and permit forces and materiel to be deployed, tracked, sustained, and

redeployed more effectively and efficiently with reduced reliance on large DoD inventories. It will also provide users, at any level, the ability to effectively interact during planning and execution, and link operations and logistics staff elements at all echelons, across selected functional areas and commands. This DTO is on the critical path to achieving Real-Time Focused Logistics and the goals articulated in *Joint Vision 2010.*

- *MD.09.J00, Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas,* is developing technologies to continuously monitor the health of individuals; assess and predict personal readiness in near-real time; detect and alert medical personnel of casualty events; provide noninvasive, computer-assisted diagnostic and patient monitoring capability and decision support for medics performing emergency resuscitation; and provide an intensive care life support system for forward casualty stabilization and use during evacuation.

Other important capabilities and technologies are being developed by other DTOs and being leveraged to the benefit of Real-Time Focused Logistics. Integrated planning technology and reliable broad-band communications are expected to migrate from the Advanced Joint Planning ACTD (F.02), Battlefield Awareness and Data Dissemination ACTD (A.07), Rapid Terrain Visualization (A.06), and Information Dominance (A.12) DTOs. The technology to improve situation awareness and visualization capability will be provided by Consistent Battlespace Understanding (IS.01.01), which puts complex tactical information in geospatial coordinates into situational assessment tools and smart presentations. Forecasting, Planning, and Resource Allocation (IS.02.01) provides automated real-time mission planning tools to analyze and select courses of action, construct and analyze forecasts, and prioritize critical objectives to establish the base point for logistics. Integrated Force and Execution Management (IS.03.01) provides real-time, multi-echelon monitoring tools that detect and display deviations from plans and provide automated recommendations for mitigation. Simulation Interconnection (IS.10.01) provides the basis for logistics simulation interoperability through common modeling and simulation infrastructure and seamless interfaces. Universal Transaction Communications (IS.20.01) and Assured Communications (IS.21.01) provide an information exchange capability that is transparent to actual interfaces and safeguards relative to firewalls and new communications bandwidths that are less susceptible to jamming.

The Military Operations in Urban Terrain ACTD (E.02) demonstrates application of physiological status monitor technologies in support of enhanced situational awareness and force protection. The sensor suites and interfaces being developed in Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas (MD.09.J00) will be integrated with computer architectures currently being developed under Force XXI Land Warrior (HS.10.05). The latter DTO, as well as other Human Systems efforts, is also developing helmet-mounted displays and other user interfaces that may be applied to telemedicine systems. For example, Joint Cognitive Systems for Battlespace Dominance (HS.06.01) develops operator interfaces and performance-aiding subsystems for integration into information processes and functions for achieving battlespace awareness. This technology may be applied to display individual health status to operational commanders. These capabilities will continue to be demonstrated in CINC-level exercises with ACTDs embedded in joint warfighting exercises and migrated into the emerging Global Combat Support System.

Additionally, a supporting part of Real-Time Focused Logistics is ensuring that a resilient, survivable, low-cost logistics infrastructure is in place to support deployment and sustainment of

forces without major interruptions. This includes key transportation nodes, facilities, and networks such as airfields, seaports, pier facilities, roads, bridges, railroad lines, communications grids and electronic facilities, lightweight power and heating/cooling units, waste disposal units, kitchen facilities, fuel storage equipment, maintenance and repair facilities, and medical support units.

Telemedicine's contribution to Real-Time Focused Logistics will require new technologies and the application of existing technologies to uniquely military health-related problems, as well as integration with other DoD initiatives in information systems, telecommunications, and human systems (described elsewhere in this document and in the DTAP). In the near to mid term, the focus is on a basic set of advanced technologies that will enable improved operational decision making, both medical and nonmedical, through increased awareness and prediction of the effects of fatigue and thermal stress on individual and unit performance. This improvement in battlespace awareness will strengthen tactical capabilities and provide better estimates of medical requirements. These technologies also will provide basic vital signs monitoring and system integration technologies for real-time, far-forward casualty care. Taken together, these capabilities should reduce battlefield morbidity and mortality and increase the efficiency of medical personnel.

Not all telemedicine-related areas of military interest can be supported with current programmed funding. Medical readiness efforts, as well as significant support in other medical areas, are derived from the DARPA program in telemedicine-related S&T, which is being sharply curtailed at the end of FY98, with continuing efforts only in the area of deployable medical imaging. Additional, as yet unfunded, initiatives are needed in the mid to far term to provide the technologies needed to extend physiological status monitoring to assess the impact of a variety of operational stressors (including chemical and biological hazards), develop a physiological status monitoring system that is fully integrated with systems for operational and medical situational awareness, increase the reliability of casualty event detection, provide advanced informatics for medical decision support, project surgical intervention capabilities forward in the theater of operations, and enhance medical training. These technologies must be validated in the outyears to provide the functional capabilities to implement the joint health service support strategy of full-spectrum health in support of the Joint Warfighter.

Table IX–10 lists demonstrations that support Real-Time Focused Logistics. Figure IX–6 illustrates how these technology developments support the Real-Time Focused Logistics JWCO. As with Tables IX–9 and IX–10, there are many DTOs from other sections that are critical to achieving Real-Time Focused Logistics.

Table IX–10. Demonstration Support—Real-Time Focused Logistics

Demonstration	Operational Capability Elements: Medical Readiness	Effective Employment	Logistics and Personnel Awareness	The Grid	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Logistics Technologies for Flexible Contingency Deployments and Operations		●	●		Air Force	F.16		
Advanced Amphibious Logistics and Seabasing for Expeditionary Force Operations ATD		●	●		Marine Corps, Navy	F.17		X
Joint Advanced Health and Usage Monitoring System ACTD		●	●	○	Army, Navy	F.18	X	
Joint Logistics ACTD		●	●	●	Joint	F.19	X	
Joint Modular Lighterage System ACTD		●	●		Marine Corps, Navy	F.20	X	
Battery Charger/Analyzer		●	●		Navy	F.22		
Modular Aircraft Support System		●	●		Air Force	F.23		
Robust/Tactical/Mobile Networking		○	●	●	DARPA	A.02		
Battlefield Awareness and Data Dissemination ACTD		●	●		DARPA	A.07	X	
Information Dominance (C^2 Protect & Attack for I/O ATD)		●	●	●	Joint	A.12		X
Military Operations in Urban Terrain ACTD			●		Joint	E.02	X	
Advanced Joint Planning ACTD		●	○		DARPA	F.02	X	
Advanced Hybrid Oxygen System		●	●		Air Force	HS.02.06		
Joint Cognitive Systems for Battlespace Dominance			○		Air Force, Navy	HS.06.01		
Force XXI Land Warrior			○		Army	HS.10.05		
Helmet-Mounted Sensory Ensemble			○		Air Force, Navy	HS.12.02		
Precision Offset, High-Glide Aerial Delivery of Munitions, Equipments, and Personnel		●	●		Army	HS.18.02		
Consistent Battlespace Understanding		●	●		Army, Navy	IS.01.01		
Forecasting, Planning, and Resource Allocation		●	●	○	Army, Air Force, Navy	IS.02.01		
Integrated Force and Execution Management		●	●	○	Army, Air Force, Navy	IS.03.01		
Simulation Interconnection		●	●	○	DMSO	IS.10.01		
Simulation Information Technologies		●	●	○	DMSO	IS.11.01		
Assured Distributed Environment Support		○	●	●	DARPA, Navy	IS.15.01		
Universal Transaction Communications		●	●	●	Army, Navy	IS.20.01		
Assured Communications		●	●	●	Joint	IS.21.01		
Digital Warfighting Communications		○	●	●	Army	IS.23.01		
Intelligent Information Technology		○	○	●	Army	IS.28.02		
Advanced Logistics Program		●	●	●	DARPA, DLA	IS.46.01		

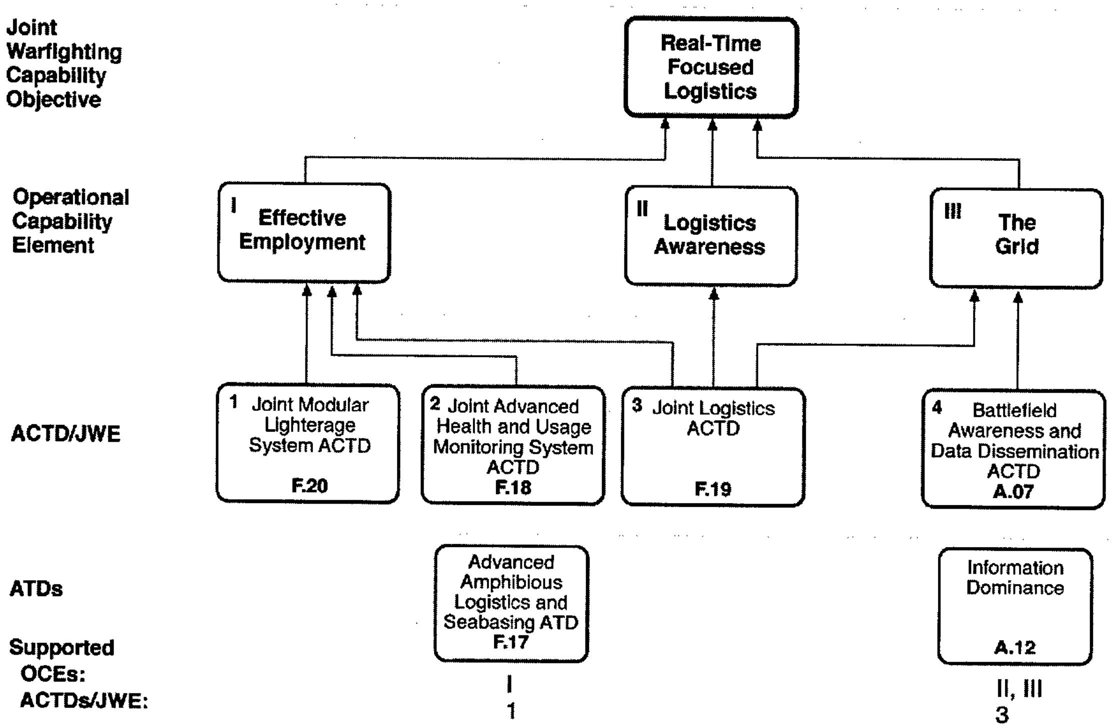
● Strong Support ○ Moderate Support

Table IX–10. Demonstration Support—Real-Time Focused Logistics (continued)

Demonstration	Operational Capability Elements: Medical Readiness	Effective Employment	Logistics and Personnel Awareness	The Grid	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas	●	●	●		DARPA, Army, Navy	MD.09.J00		
Affordable Sustainment of Aging Aircraft Systems		●	●		Army, Air Force, Navy	MP.07.06		
Higher Sea State Logistics Support for Expeditionary Forces ATD		●	●		Marine Corps, Navy	MP.12.11		X
D-Day Fuel Support for Expeditionary Forces ATD		●	●		Navy	MP.13.11		X
Wartime Contingencies and Bare Airbase Operations		●	●		Air Force	MP.14.11		
Firefighting Capabilities for the Protection of Weapon Systems		●	●		Air Force, Navy, Army	MP.16.06		
Airfields and Pavements To Support Force Protection		●	●		Army, Air Force, Navy	MP.17.11		
Life-Extension Capabilities for the Navy's Aging Waterfront Infrastructure ATD		●	●		Navy	MP.18.11		X
Fast, Affordable Product Realization		●	●		Air Force	MP.32.01		
Optical Processing and Memory		○	○		DARPA, Air Force	SE.35.01		

● Strong Support ○ Moderate Support

Figure IX–7 is the roadmap for developing and demonstrating the technologies required to support the advancements in functional and operational capabilities that affect Real-Time Focused Logistics. The roadmap shows how total visibility of all warfighting resources can be achieved with advances in information collection and management, broadband communications, and distributed simulations. This visibility allows predictive planning and preemption, integrated logistics and health service support management, and time-critical execution of missions. These integrated tools enable faster acquisition of material; total visibility of the logistics pipeline; visibility of personnel and rapid, enhanced casualty response; optimal scheduling of lift assets; and collaborative planning, execution monitoring, and dynamic replanning. In parallel, Information Superiority (Chapter IV) will be developing the sensing, fusion, and visualization technologies needed to supply reliable inputs to this entire process while Materials/Processes (DTAP, Chapter V) will be developing technologies necessary to extend the useful life of the support infrastructure to make Real-Time Focused Logistics effective and affordable.



Supporting DTOs

JWSTP

E.02	Military Operations in Urban Terrain ACTD
F.02	Advanced Joint Planning ACTD
F.16	Logistics Technologies for Flexible Contingency Deployments and Operations
F.22	Battery Charger/Analyzer
F.23	Modular Aircraft Support System

DTAP

HS.02.06	Advanced Hybrid Oxygen System
HS.06.01	Joint Cognitive Systems for Battlespace Dominance
HS.10.05	Force XXI Land Warrior
HS.12.02	Helmet-Mounted Sensory Ensemble
HS.18.02	Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel
IS.01.01	Consistent Battlespace Understanding
IS.02.01	Forecasting, Planning, and Resource Allocation
IS.03.01	Integrated Force and Execution Management
IS.10.01	Simulation Interconnection
IS.11.01	Simulation Information Technologies
IS.15.01	Assured Distributed Environment Support
IS.20.01	Universal Transaction Communications
IS.21.01	Assured Communications
IS.23.01	Digital Warfighting Communications
IS.28.02	Intelligent Information Technology
IS.46.01	Advanced Logistics Program
MD.09.J00	Advanced Medical Technology—Advanced Field Medical Support in Forward Combat Areas
MP.07.06	Affordable Sustainment of Aging Aircraft Systems
MP.12.11	Higher Sea State Logistics Support for Expeditionary Forces ATD
MP.13.11	D-Day Fuel Support for Expeditionary Forces ATD
MP.14.11	Wartime Contingencies and Bare Airbase Operations
MP.16.06	Firefighting Capabilities for the Protection of Weapon Systems
MP.17.11	Airfields and Pavements To Support Force Projections
MP.18.11	Life Extension Capabilities for the Navy's Aging Waterfront Infrastructure ATD
MP.32.01	Fast, Affordable Product Realization
SE.35.01	Optical Processing and Memory

Figure IX–6. Technology to Capability—Real-Time Focused Logistics

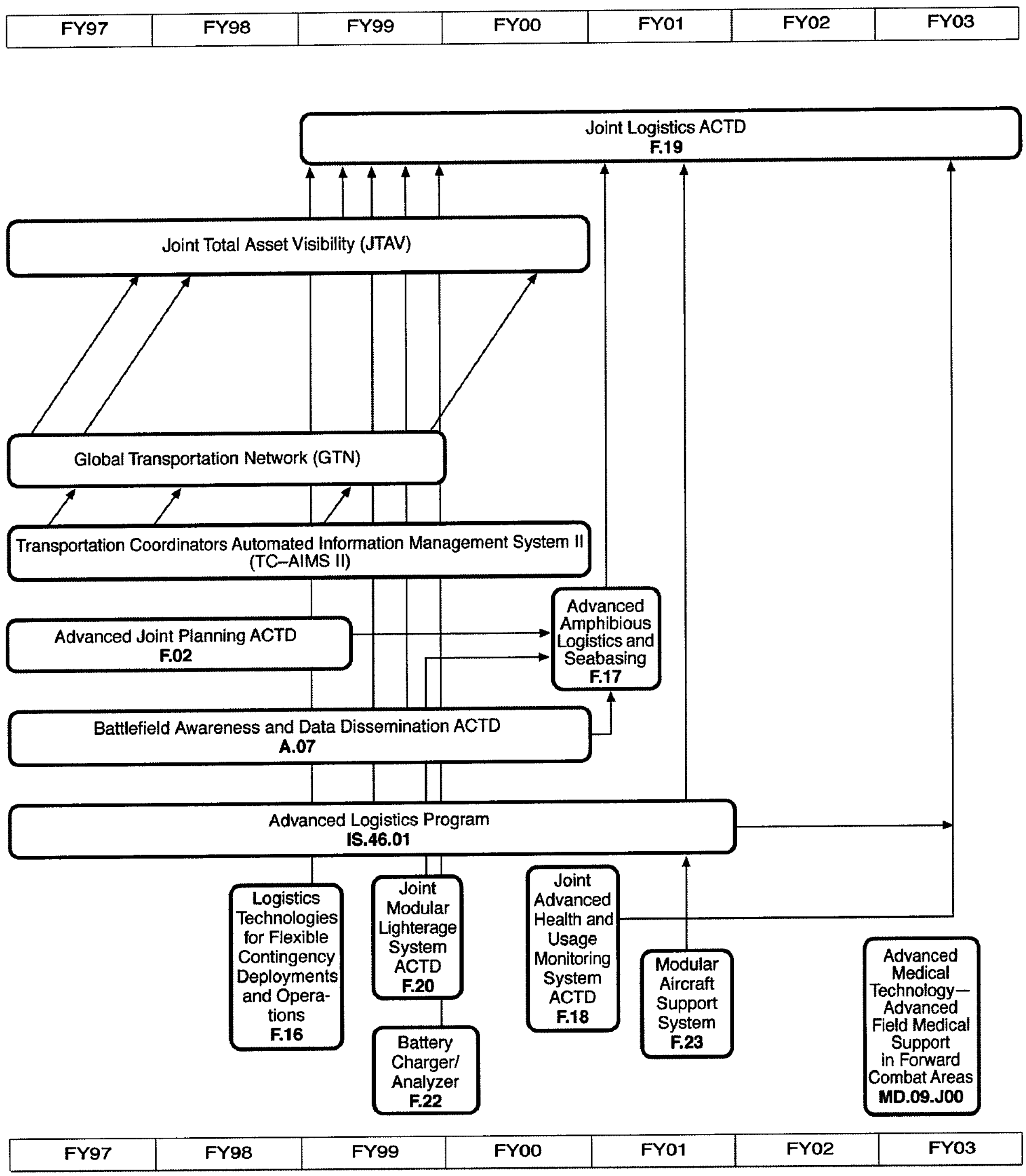


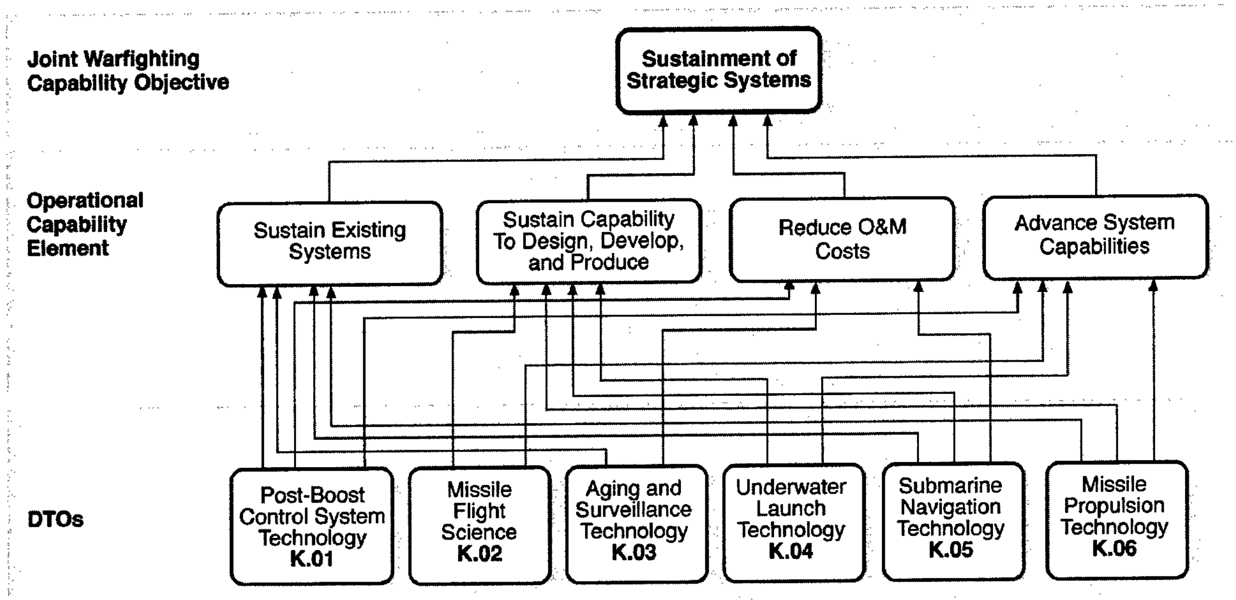
Figure IX–7. Roadmap—Real-Time Focused Logistics

3. Sustainment of Strategic Systems

Figure IX–8 shows the technology developments supporting (1) sustainment of existing strategic systems; (2) sustainment of the capability to design, develop, and produce new strategic systems; (3) reduction of O&M costs; and (4) advancement of the capabilities of strategic systems. Table IX–11 lists the DTOs for strategic systems sustainment. Table IX–12 points out the relationship between these DTOs and the operational capability elements, and Figure IX–8 shows the relationship between DTOs. Figure IX–9 shows the schedule for achieving the DTOs in a technology roadmap.

The JWSTP DTOs are as follows:

- *K.01, Post-Boost Control System Technology,* will develop and demonstrate commercially available, high-temperature/high-strength materials and components that meet the Trident Post-Boost Vehicle operational requirements by FY03. It will also develop and demonstrate effective seal materials for the Minuteman Post-Boost Vehicle. Decreased hardware costs of 25 percent will be demonstrated.
- *K.02, Missile Flight Science,* will develop and demonstrate an integrated strategic missile design and analysis tool by FY04. This effort addresses solid-propellant ignition response and efforts, nuclear survivability, and drag reduction devices. It will reduce the reliance on disappearing experts and expensive or no longer available test facilities.
- *K.03, Aging and Surveillance Technology,* will develop improved understanding of aging phenomena, improved surveillance evaluation technologies, and improved service life prediction codes for ballistic missiles. This effort addresses goals of reducing the time and cost of surveillance, and increasing missile service life predictions. It will demonstrate an increase in prediction capability from 5 years to 10 years by FY03, and a 50 percent decrease in both processing time and costs for nondestructive evaluations by FY03.
- *K.04, Underwater Launch Technology,* will develop and demonstrate an underwater launch design and analysis tool that includes historical data from past missile development efforts by FY03. This effort addresses integrated launch models, an electronic interactive database, and test facility design criteria and rationale. It treats the underwater flight physics of submarine-launched strategic missiles from gas generator ignition to initiation of powered flight.
- *K.05, Submarine Navigation Technology,* will develop and demonstrate technologies for a strategic submarine navigation system that is common with other navigation systems by FY01. This effort addresses unique, single-source items for the current navigator that are either very costly or no longer manufactured.
- *K.06, Missile Propulsion Technology,* will develop a Class 1.3 solid propellant and associated propulsion system components that will meet all ballistic missile requirements by FY03. The propellant will be available to replace the more shock-sensitive propellant on the Trident missile. This effort will also demonstrate increased system mass fraction of 1 percent, increased system-delivered energy of 4 percent, and decreased hardware costs of 25 percent.



AP.02.00	Fixed-Wing Vehicle Structures Technology
AP.03.00	Aircraft Support/Sustainment Reduction
AP.04.00	Flight Control Technology for Affordable Global Reach/Power
AP.08.00	Fighter/Attack/Strike Propulsion
AP.10.00	Cruise Missile/Expendable Propulsion
CB.10.07	Nuclear Hardness and Survivability Testing Technologies
CB.12.01	Electronic System Radiation Hardening
CB.13.07	Hard-Target Defeat
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.15.01	Balanced Electromagnetic Hardening Technology
CB.17.01	Survivability Assessments Technology
CB.18.01	Integrated Comprehensive Weaponeering Capability
MP.03.01	Nondestructive Evaluation for System Life
MP.04.01	Materials and Processes for Reentry Vehicle Technology
MP.07.06	Affordable Sustainment of Aging Aircraft Systems
MP.10.06	Interferometric Fiber-Optic Gyroscope Flexible Manufacturing ATD
SE.24.02	Advanced Common Electronic Modules
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.55.01	Space Radiation Mitigation for Satellite Operations
SP.10.06	Liquid Boost Propulsion
SP.15.06	Protection Technologies
WE.21.02	Fiber-Optic, Gyro-Based Navigation Systems
WE.57.02	Lethality/Vulnerability Models for High-Value Fixed Targets

Figure IX–8. Technology to Capability—Sustainment of Strategic Systems

Table IX–11. Defense Technology Objectives— Sustainment of Strategic Systems

DTO No.	Title
K.01	Post-Boost Control System Technology
K.02	Missile Flight Science
K.03	Aging and Surveillance Technology
K.04	Underwater Launch Technology
K.05	Submarine Navigation Technology
K.06	Missile Propulsion Technology
AP.02.00	Fixed-Wing Vehicle Structures Technology
AP.03.00	Aircraft Support/Sustainment Reduction
AP.04.00	Flight Control Technology for Affordable Global Reach/Power
AP.08.00	Fighter/Attack/Strike Propulsion
AP.10.00	Cruise Missile/Expendable Propulsion
CB.10.07	Nuclear Hardness and Survivability Testing Technologies
CB.12.01	Electronic System Radiation Hardening
CB.13.07	Hard-Target Defeat
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.15.01	Balanced Electromagnetic Hardening Technology
CB.17.01	Survivability Assessments Technology
CB.18.01	Integrated Comprehensive Weaponeering Capability
MP.03.01	Nondestructive Evaluation for System Life
MP.04.01	Materials and Processes for Reentry Vehicle Technology
MP.07.06	Affordable Sustainment of Aging Aircraft Systems
MP.10.06	Interferometric Fiber-Optic Gyroscope Flexible Manufacturing ATD
SE.24.02	Advanced Common Electronic Modules
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.55.01	Space Radiation Mitigation for Satellite Operations
SP.10.06	Liquid Boost Propulsion
SP.15.06	Protection Technologies
WE.21.02	Fiber-Optic, Gyro-Based Navigation Systems
WE.57.02	Lethality/Vulnerability Models for High-Value Fixed Targets

Table IX–12. Demonstration Support—Sustainment of Strategic Systems

Demonstration	Operational Capability Elements: Sustain Existing Systems	Sustain Capability to Design, Develop, and Produce	Reduce O&M Costs	Advance System Capabilities	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Post-Boost Control System Technology	●	●	○	○	Air Force, Navy	K.01		
Missile Flight Sciences		●		○	Navy	K.02		
Aging and Surveillance Technology	●		●	○	Air Force	K.03		
Underwater Launch Technology		●		○	Navy	K.04		
Submarine Navigation Technology	●	●	●	○	Navy	K.05		
Missile Propulsion Technology	●	●	○	●	Air Force	K.06		
Fixed-Wing Vehicle Structures Technology		●		○	Air Force, Navy	AP.02.00		
Aircraft Support/Sustainment Reduction	●	●	●	○	Air Force	AP.03.00		
Flight Control Technology for Affordable Global Reach/ Power				●	Air Force, Navy	AP.04.00		
Fighter/Attack/Strike Propulsion	○	○	○	●	Air Force, Navy	AP.08.00		
Cruise Missile/Expendable Propulsion	○	○	○	●	Air Force, Navy	AP.10.00		
Nuclear Hardness and Survivability Testing Technologies	●	●	●	●	DSWA	CB.10.07		
Electronic System Radiation Hardening	●	●	●	●	DSWA	CB.12.01		
Hard-Target Defeat	○	○	○	○	DSWA	CB.13.07		
Prediction and Mitigation of Collateral Hazards	○	○	○	○	DSWA	CB.14.07		
Balanced Electromagnetic Hardening Technology	●	●	●	●	DSWA	CB.15.01		
Survivability Assessments Technology	●	●	●	●	DSWA	CB.17.01		
Integrated Comprehensive Weaponeering Capability				●	DSWA	CB.18.01		
Nondestructive Evaluation for System Life	●		●		Air Force, Navy	MP.03.01		
Materials and Processes for Reentry Vehicle Technology	●	○	●	○	Air Force, Navy	MP.04.01		
Affordable Sustainment of Aging Aircraft Systems	●		●		Air Force, Navy	MP.07.06		
Interferometric Fiber-Optic Gyroscope Flexible Manufacturing ATD	●	●	●	●	Air Force, DARPA	MP.10.06		X
Advanced Common Electronics Modules				●	Navy, DARPA	SE.24.02		
High-Density, Radiation-Resistant Microelectronics	●	●	●	●	Air Force, DSWA	SE.37.01		
Space Radiation Mitigation for Satellite Operations	○	○	○	○	Air Force	SE.55.01		
Liquid Boost Propulsion	○			●	Air Force	SP.10.06		
Protection Technologies	○	○	○	○	Air Force	SP.15.06		
Fiber-Optic, Gyro-Based Navigation Systems	○		○	○	Navy, DARPA	WE.21.02		
Lethality/Vulnerability Models for High-Value Fixed Targets				●	DSWA	WE.57.02		

● Strong Support ○ Moderate Support

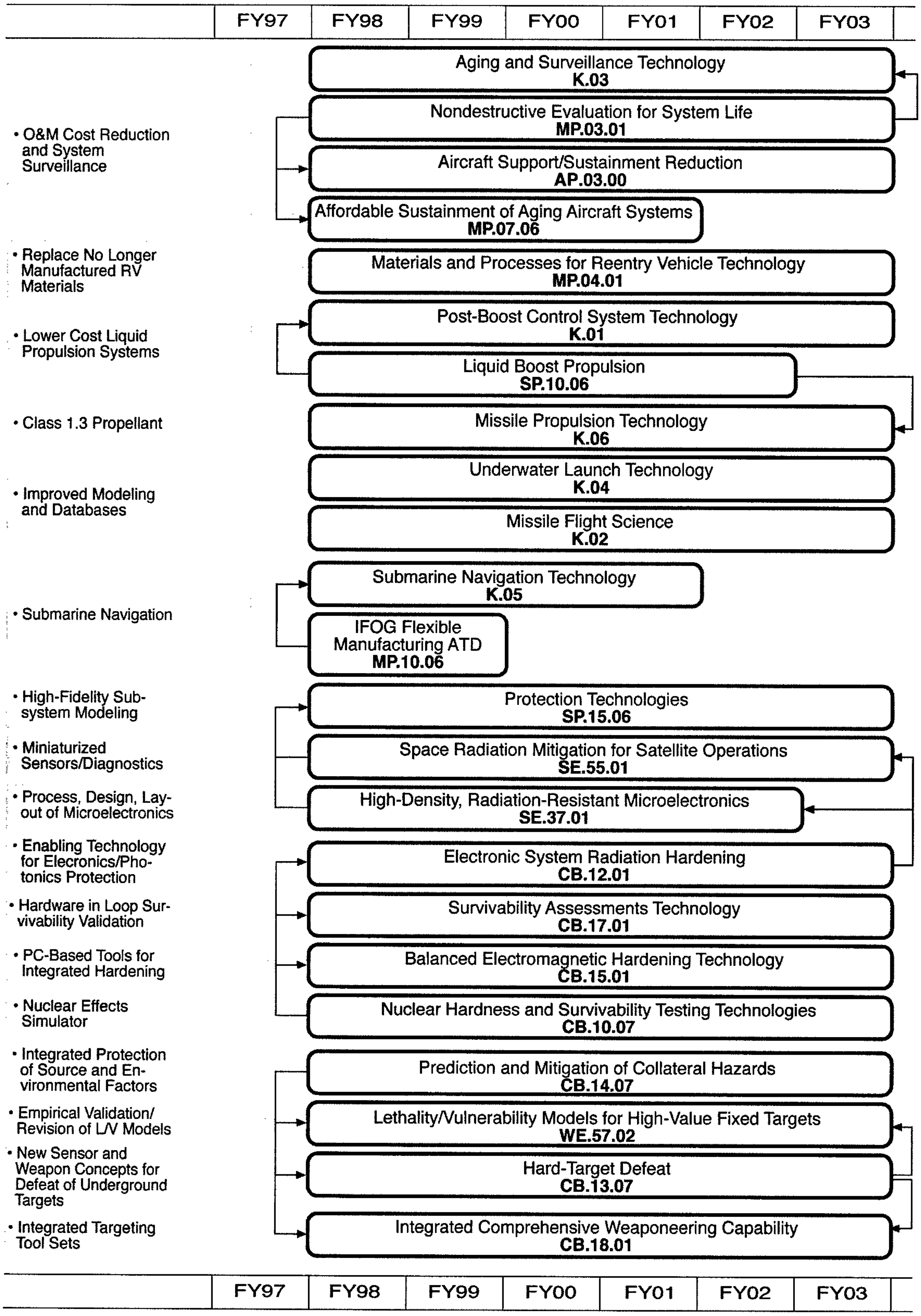


Figure IX–9. Roadmap—Sustainment of Strategic Systems

The Technology for Sustainment of Strategic Systems IPT addresses six of the highest priority sustainment needs identified by the U.S. Strategic Command. Post-Boost Control System Technology (K.01) is developing post-boost vehicle technologies based on more robust and commercially available material and processes and leverages Liquid Boost Propulsion (SP.10.06). Missile Propulsion Technology (K.06) is developing a sustainable class 1.3 ballistic missile propellant. Missile Flight Science (K.02) captures ballistic missile flight science and analytical capability in a modern analysis and design tool. Aging and Surveillance Technology (K.03) will increase the look-ahead window for ballistic missile service life from 5 to 10 years. Technology that could contribute to this objective is under development in Nondestructive Evaluation for System Life (MP.03.01), Aircraft Support/Sustainment Reduction (AP.03.00), and Affordable Sustainment of Aging Aircraft Systems (MP.07.06). Underwater Launch Technology (K.04) is developing the tool set needed for rapid design and analysis of current and future SLBM designs. Submarine Navigation Technology (K.05) is developing fiber optic gyro navigation systems for SSBNs. Related technology is being demonstrated in Interferometric Fiber-Optic Gyroscope Flexible Manufacturing ATD (MP.10.06) and Fiber-Optic, Gyro-Based Navigation Systems (WE.21.02). Materials and Processes for Reentry Vehicle Technology (MP.04.01) will develop advanced nosetip, heatshield, and antenna window materials and processes to maintain current ICBM and SLBM reentry systems through at least 2020.

The Radiation Hardened Electronics IPT developed an investment strategy to ensure that DoD technology requirements for radiation-resistant systems were met. S&T activities focus on long-lead development of enabling technologies; related program office investments develop system-specific technology applications. Key S&T investments in these requirements are presented in Electronic System Radiation Hardening (CB.12.01) and High-Density, Radiation-Resistant Microelectronics (SE.37.01). Three associated DTOs develop the technologies and capabilities needed for validating strategic system survivability: Nuclear Hardness and Survivability Testing Technologies (CB.10.07), Balanced Electromagnetic Hardening Technology (CB.15.01), and Survivability Assessments Technology (CB.17.01). System-level applications of survivability technologies include Space Radiation Mitigation for Satellite Operations (SE.55.01) and Protection Technologies (SP.15.06). Developing an improved capability for system hardening against radiation hazards is a thrust within Missile Flight Science (K.02).

Improved capabilities for planning and executing strategic force missions are developed in Integrated Comprehensive Weaponeering Capability (CB.18.01), Hard-Target Defeat (CB.13.07), Lethality/Vulnerability Models for High-Value Fixed Targets (WE.57.02), and Prediction and Mitigation of Collateral Hazards (CB.14.07).

The basis for improvements in the performance and sustainability of air-breathing strategic systems (bombers and cruise missiles) is provided in Fixed-Wing Vehicle Structures Technology (AP.02.00), which focuses on significant reductions in weight and fabrication costs; Flight Control Technology for Affordable Global Reach/Power (AP.04.00), which offers reduced reliance on aircraft hydraulics; and DTOs contributing to the Integrated High-Performance Turbine Engine Technology Program, notably Fighter/Attack/Strike Propulsion (AP.08.00) and Cruise Missile/Expendable Propulsion (AP.10.00).

Enabling technologies for improved platform electronics are being developed in Advanced Common Electronics Modules (SE.24.02), which achieves 10:1 and 8:1 reductions in weight and life-cycle costs, respectively.

F. SUMMARY

1. Joint Readiness

Joint readiness is directly affected by many of the other JWCOs in this JWSTP and by many of the technology DTOs in the DTAP. However, the operational capabilities of the training, planning, assessment, and industrial readiness are essential elements that must be addressed. Developments in technology promise advancements in these capabilities in the near, mid, and long term, as illustrated in Figure IX–10.

2. Real-Time Focused Logistics

The current logistics environment consists of disparate databases, compartmentalized by functional disciplines—material acquisition, supply and storage, maintenance, transportation, and traffic management; medical support and evacuation; and more. Future operations will demand that logistics planning be conducted concurrently with warfighting planning and development of the warfighting concept of operations so that total visibility into the entire logistics pipeline can be maintained and the impact of logistics plans on the CINCs' warfighting plan and vice versa are immediately apparent. Only by applying and advancing information systems technology can these capabilities be met.

Real-Time Focused Logistics is at the heart of our ability to generate and support overwhelming combat power. It is the national capability that will deliver and sustain combat operation wherever and whenever needed. Real-Time Focused Logistics binds the logistics disciplines into a seamless interoperable process, using the information processing technologies outlined in Figure IX–11, to create operational capabilities for planning, execution monitoring, and replanning.

Telemedicine applications of Real-Time Focused Logistics are fundamental for achieving an underlying DoD goal of containing health care costs while improving operational and medical decision making, and providing quality health care across the spectrum of battlespace and operational conditions. Logistics planning will be conducted concurrently with warfighting operational planning and will influence future battlefield decisions. Future logistics systems must exploit state-of-the-art distributed systems architectures, current-state measurements from automated identification and other technologies, and heterogeneous database access and maintenance techniques. These must be supported by an assured, reliable, robust logistics communications infrastructure for continuous visibility of the logistics pipeline. It is only through the complex linkage of operational and logistics planning, execution monitoring, dynamic replanning, and end-to-end system visibility that success can be ensured in future operations.

3. Sustainment of Strategic Systems

The incremental advances provided by the DTOs discussed in this chapter are portrayed in Figure IX–12. Between 1998 and 2004, the ability to support the operational capability elements of sustaining existing strategic systems; reducing O&M costs; sustaining the capability to design, develop, and produce strategic systems; and advancing the capabilities of strategic systems, will be significantly improved. Enabling technology for radiation hardening of microelectronics will be developed for 0.5-, 0.35-, and 0.25-μm devices; this will enable use of more capable modern

microelectronics in strategic systems. Technologies for an improved, lower cost SSBN navigation system will be developed. A Class 1.3 propellant suitable for use in SLBMs will be demonstrated. The look-ahead window for monitoring strategic systems will be increased from 5 to 10 years, and the cost of systems surveillance will be reduced.

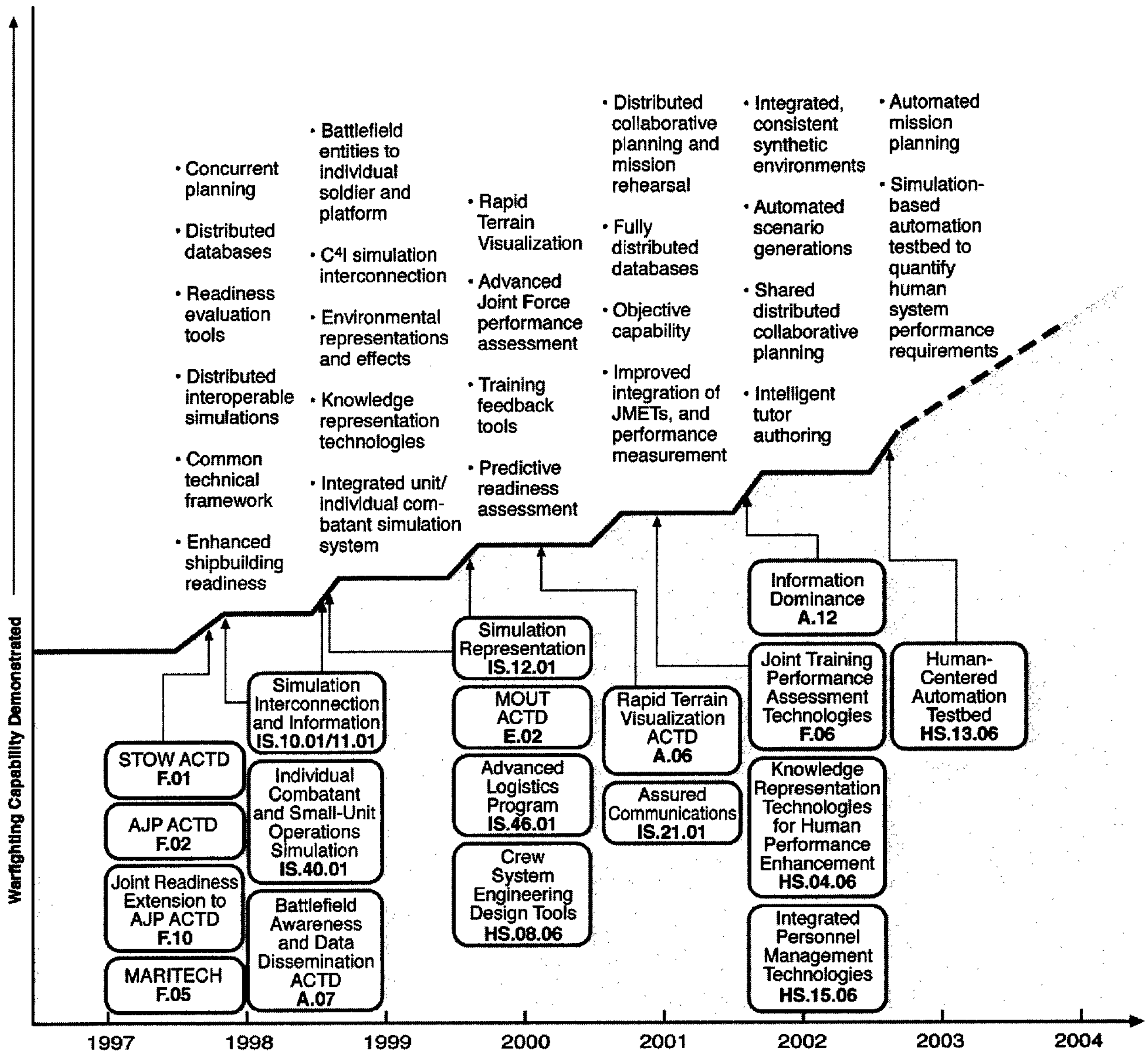


Figure IX–10. Progress—Joint Readiness

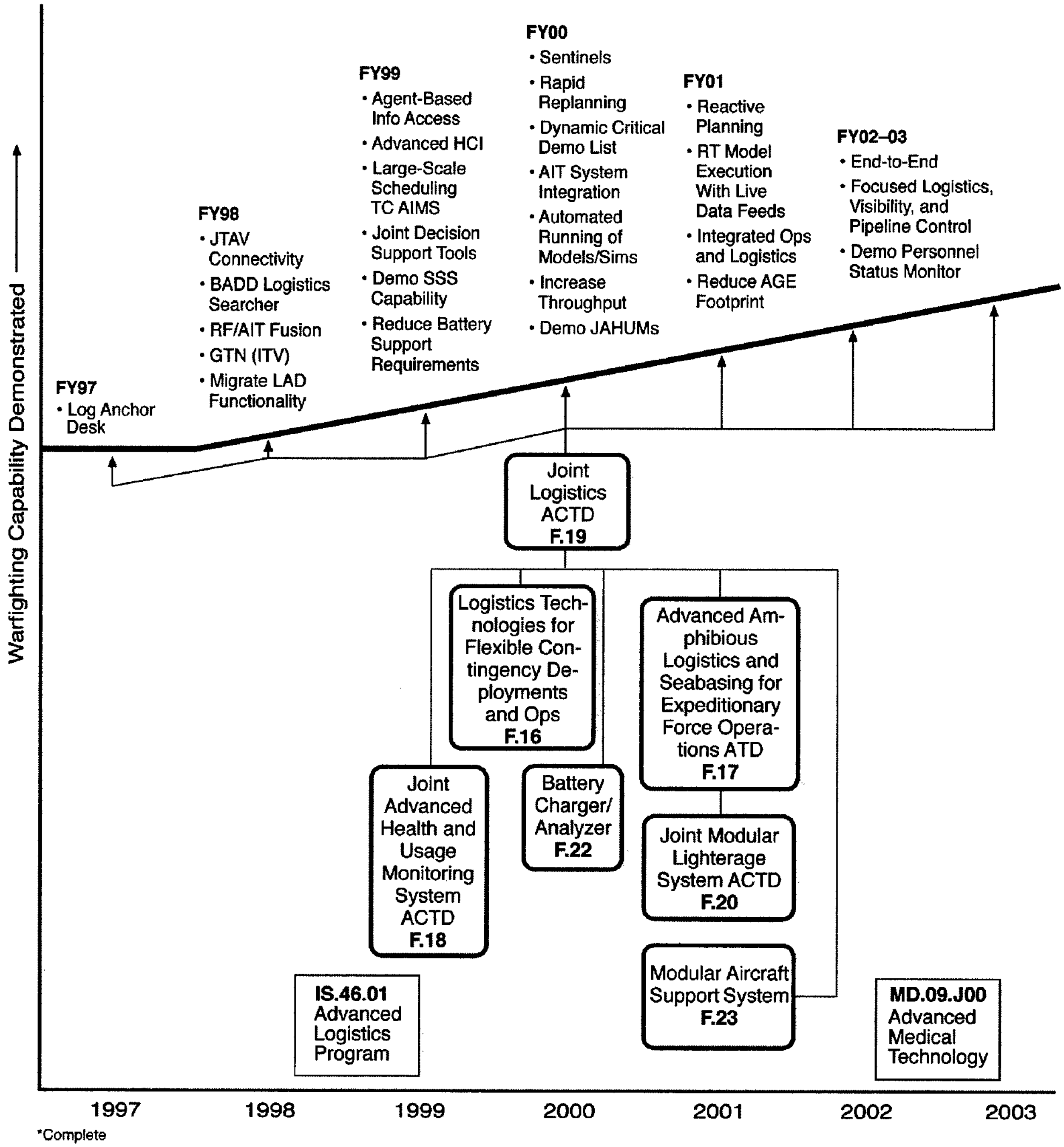


Figure IX–11. Progress—Real-Time Focused Logistics

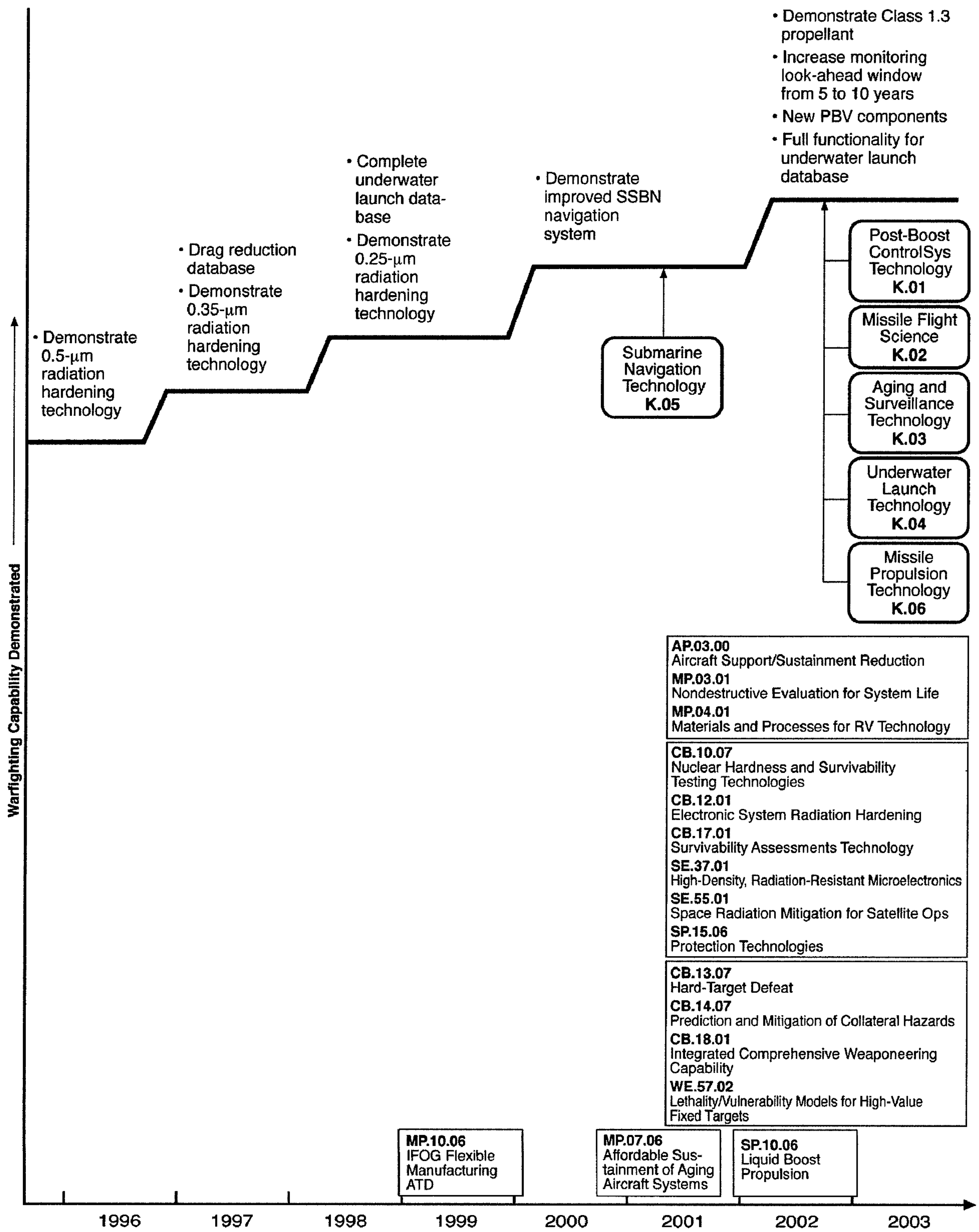


Figure IX–12. Progress—Sustainment of Strategic Systems

CHAPTER X

FORCE PROJECTION/DOMINANT MANEUVER

CHAPTER X
FORCE PROJECTION/DOMINANT MANEUVER

A. DEFINITION

Force Projection/Dominant Maneuver is the capability for fast deployment and timely employment and maneuver of joint forces to rapidly dominate across the full range of military operations with minimum casualties. This capability supports requirements to rapidly deploy and employ a decisive force with minimum use of lift resources and forward-based requirements. It includes enhanced capabilities in operational and tactical maneuver, joint countermine, individual and platform mobility, situation awareness, sustained logistics support, reconnaissance and intelligence, and integration of air-, land-, and sea-based maneuver and weapon systems. Joint countermine is the capability for assured, rapid surveillance, reconnaissance, detection, and neutralization of mines to enable forced entry by expeditionary forces. It also includes the capability to control the sea and to conduct amphibious and ground force operational maneuvers against hostile defensive forces employing sea, littoral, and land mines. For land forces, dominance means the ability to conduct in-stride tempo operations in the face of severe land mine threats.

Present contingency forces capable of providing a timely response (within hours or days) to time-urgent threats to national security lack the firepower needed to achieve operational dominance. To achieve that dominance requires a buildup of forces that may take weeks to months.

Force Projection/Dominant Maneuver provides the capability to better respond to such threats by enabling rapidly deployable forces to swiftly achieve dominance (for a limited period of time) against potential threats in most operational environments, including urban terrain. It will do so by exploiting emerging technologies to make smaller forces more lethal, through provision of theater-wide situation understanding and access to effective remote fires by way of a deployable, robust, interconnected information infrastructure. In effect, Force Projection/Dominant Maneuver substitutes fires for forces.

Force Projection/Dominant Maneuver couples these emerging technologies to a redesigned force that normally operates as small, light, agile units. These units will operate in highly dispersed postures, presenting few concentrated targets for the enemy. This both enhances the force's survivability and extends its area of influence. When required, these units can rapidly coalesce into larger fighting formations.

Situation understanding is provided by a multilayered suite of sensors (ranging from space-based to unattended ground sensors), linked to the warfighter, via the information infrastructure, through a personnel information ensemble based on commercial cellular and digital datalink assistant technologies that is able to provide paging, conferencing, and imaging services. This information infrastructure is characterized by a distributed processing environment linked via a self-managed, adaptive multimedia data transport element. It consists of adaptive, reconfigurable ground-based local area networks, linked to medium-area networks whose connectivity is provided by cross-linked air vehicles, which are in turn linked to spaceborne platforms providing global connectivity. The ability to transmit via a common datalink protocol allows all forces to share a common picture of the battlespace. Everyone from the commander to the lowest level warfighter, and all

support personnel and organizations in between, share the same situation awareness. That does not mean that every level of the fighting force shares the same picture, but rather that all have relevant pieces of one common picture. Common, digital datalinks also allow rapidly deployed forces to receive needed information while en route to their theater of operation. This will ensure that the forces enter the theater armed not only with the weapons needed to begin operations but, just as important, the knowledge and situation awareness to begin operations.

These rapidly deployable forces employ precision remote fires to inflict damage to the enemy, halt attacks, gain a foothold, and temporarily control territory prior to the arrival of more extensive follow-on forces. Additional roles include conducting major raids, securing points of debarkation for follow-on forces, locating and neutralizing weapons of mass destruction (WMD), and complementing remote sensors by filling gaps and resolving ambiguities about target characteristics (e.g., identifying noncombatants and locating dismounted forces) and integration with coalition forces. Advanced airborne forces are provided with digital real-time targeting information to allow them to secure the airspace above the ground component, thus freeing those forces of the threat from above.

Sealift and airlift are means by which these forces will be deployed. Deployability is enhanced by reducing the number of combat support and combat service support functions that must be performed on the ground, in theater. Employment of remote fires significantly reduces the ground element's need for organic indirect-fire weapons (artillery) and hence for in-theater, on-the-ground logistics. Command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR) functions, which are performed today by on-the-ground, in-theater assets, will be provided remotely via the information infrastructure.

Mines and obstacles pose a significant threat to the ability to project U.S. forces and to achieve Force Projection/Dominant Maneuver. Force Projection/Dominant Maneuver requires that U.S. forces have a capability to counter the mine threat in all environments. For naval forces, this necessitates unencumbered passage in support of joint strategic mobility, freedom of maneuver in operating areas in support of joint strike warfare, and rapid movement in amphibious operating areas in support of joint littoral warfare. For land-based forces, this requires control of the land to enable rapid maneuver in joint littoral and land warfare as well as in joint regional engagement/presence missions such as peacekeeping.

Joint Countermine is one of the essential keys to unlocking control of the battlespace. Joint Countermine provides the capability for assured and rapid surveillance, reconnaissance, detection, and neutralization of mines to enable Force Projection/Dominant Maneuver. It includes the ability to conduct amphibious and ground force operational maneuvers against hostile defensive forces employing sea, anti-invasion, and land mines. For land forces, it includes the ability to conduct in-stride operations in the face of severe land mine threats.

Unexploded ordnance (UXO) detection and clearance are difficult and complex technical problems. UXO includes Joint Countermine operations—detecting and dealing with landmines in a combat environment; and explosive ordnance disposal—detecting and neutralizing unexploded ordnance in peacetime, in combat operations, and in operations other than war. An additional thrust has been added to this year's submission of the Joint Warfighter's required capabilities: humanitarian demining (HD)—detecting and neutralizing landmines scattered indiscriminately by warring parties in many nations of the world.

A DoD Integrated Process Team (IPT) identified the need to continue strong focus within the Defense Department to ensure oversight and coordination of technology developments supporting UXO clearance and to preclude duplication of efforts. As a result, DoD has set up a UXO Center of Excellence (COE) to establish standards for testing, modeling, and evaluation of UXO clearance technology. Oversight of the UXO COE is provided by the Under Secretary of Defense for Acquisition and Technology through a Joint UXO Board of Directors and a Joint UXO Coordination Office (JUXOCO). The UXO Center of Excellence will support the Joint Warfighters and Acquisition communities, with the JUXOCO serving as an integrating and coordinating agent in DoD for UXO technology development managers. Details of the DoD initiatives are described in a USD(A&T) report to Congress on UXO clearance (Reference 19).

In June 1997, the Director (Acting) of Defense Research and Engineering (DDR&E) briefed the White House Office of Science and Technology Policy (OSTP) on three new Multidisciplinary University Research Initiatives (MURIs) addressing humanitarian demining. These MURIs focus on critically needed technology for rapid development and transition to products.

Technology developments in automatic target recognition (ATR) are also reflected in this year's submission of DTOs for Joint Countermine efforts. An IPT on ATR, chartered by the DDR&E in December 1996, developed a DoD S&T investment strategy for practical, affordable ATR through enhanced evaluation, advanced processing, and advanced sensor technology. The findings and recommendations from the ATR IPT are being applied to the Joint Countermine efforts through coordination with the UXO COE.

Joint Countermine activities, including humanitarian demining, are critical Joint Warfighter capabilities and are reflected in this focused, coordinated technology plan.

B. OPERATIONAL CAPABILITY ELEMENTS

1. Projection and Maneuver Dominance

Figure X–1 depicts the essence of the Force Projection/Dominant Maneuver concept. The rapidly deployable force consists of light, agile ground units and suites of sensors and "shooters," all connected by a robust information infrastructure. This force is very potent—capable of dominating the battlefield for a limited period of time and thus prepare the way for more capable, but slower, arriving forces. The force is distributed and disaggregated, empowered by unprecedented situation understanding, dependent on remote fires, connected by a robust information infrastructure, and supported by precision logistics.

Figure X–2 illustrates the critical role of remote precision fires to the Force Projection/Dominant Maneuver concept. The force will have a real-time capability to manage ensembles of both sensor and weapon systems, including the ability to call for and receive specific pairing of sensor systems and strike packages that most cost effectively match target and targeting characteristics. Second, there is a critical role in the weapon ensemble for loitering weapons and real-time inflight updates to provide the responsiveness needed to engage time-urgent and mobile targets. The ensemble of indirect-fire weapons must be capable of engaging all types of tactical targets. Third, the force will employ means to identify critical targets that can then be observed, put into "track," and "tagged." This will permit the commander to schedule fires to hit targets when and where they

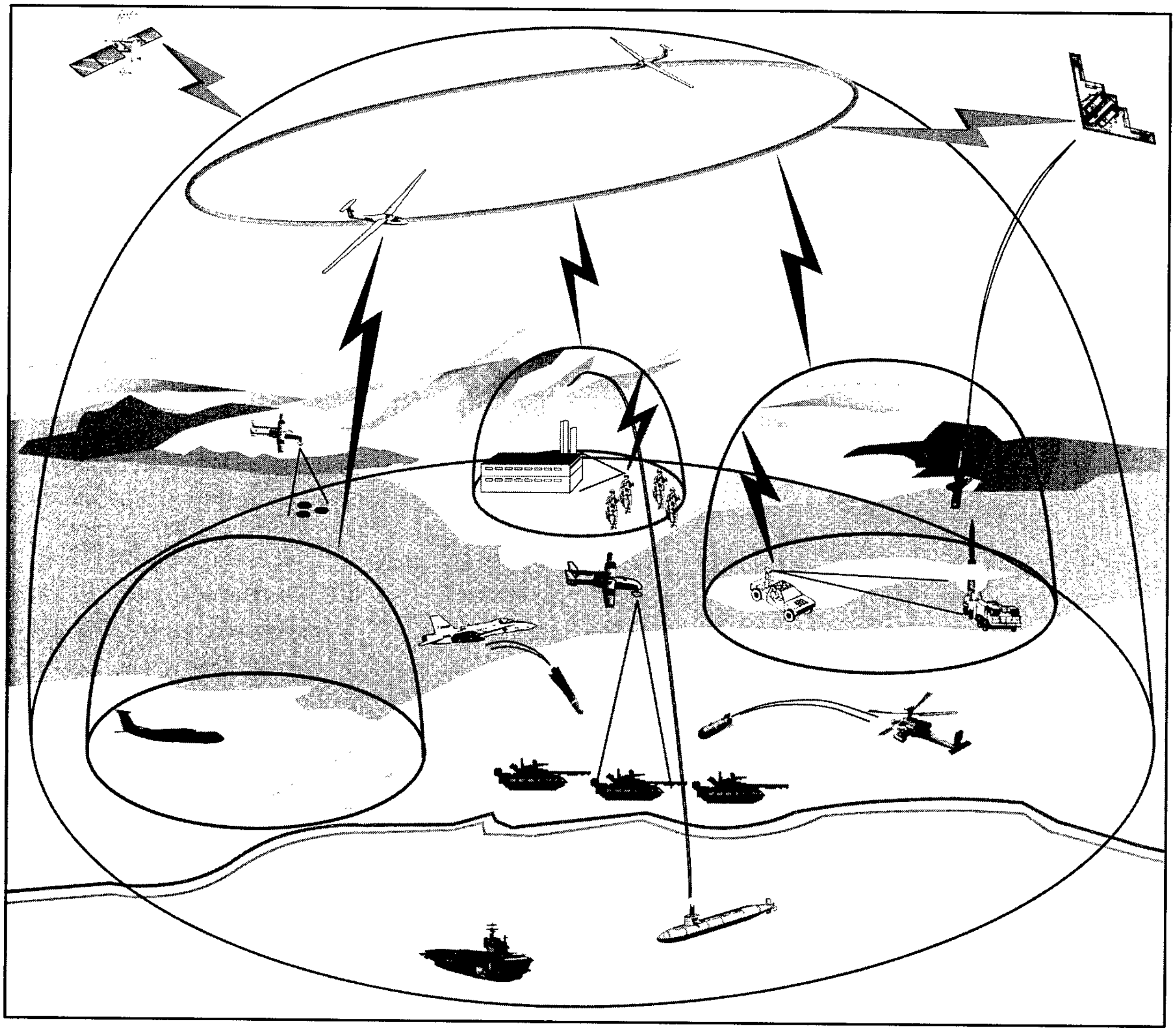


Figure X–1. Concept—Force Projection/Dominant Maneuver

are most valuable and vulnerable. Fourth, the battle damage assessment function must be integral to the strike package—that is, capable of relaying this information back to the commander in near-real time (minutes after each strike) and, in some cases, integrating the information into the strike weapon itself.

There are six principal operational capability elements inherent in Force Projection/ Dominant Maneuver:

- *Comprehensive Situation Understanding*—a comprehensive, shared picture of the battlespace. This picture is derived in large measure by fusing the data (high-resolution, multispectral, geometrically diverse) from multiple sensors carried on a variety of platforms, such as satellites, aircraft, unmanned aerial vehicles, micro air vehicles, and unattended ground sensors, providing the commander at every echelon a comprehensive understanding of the tactical situation within his area of interest, or "bubble," within the

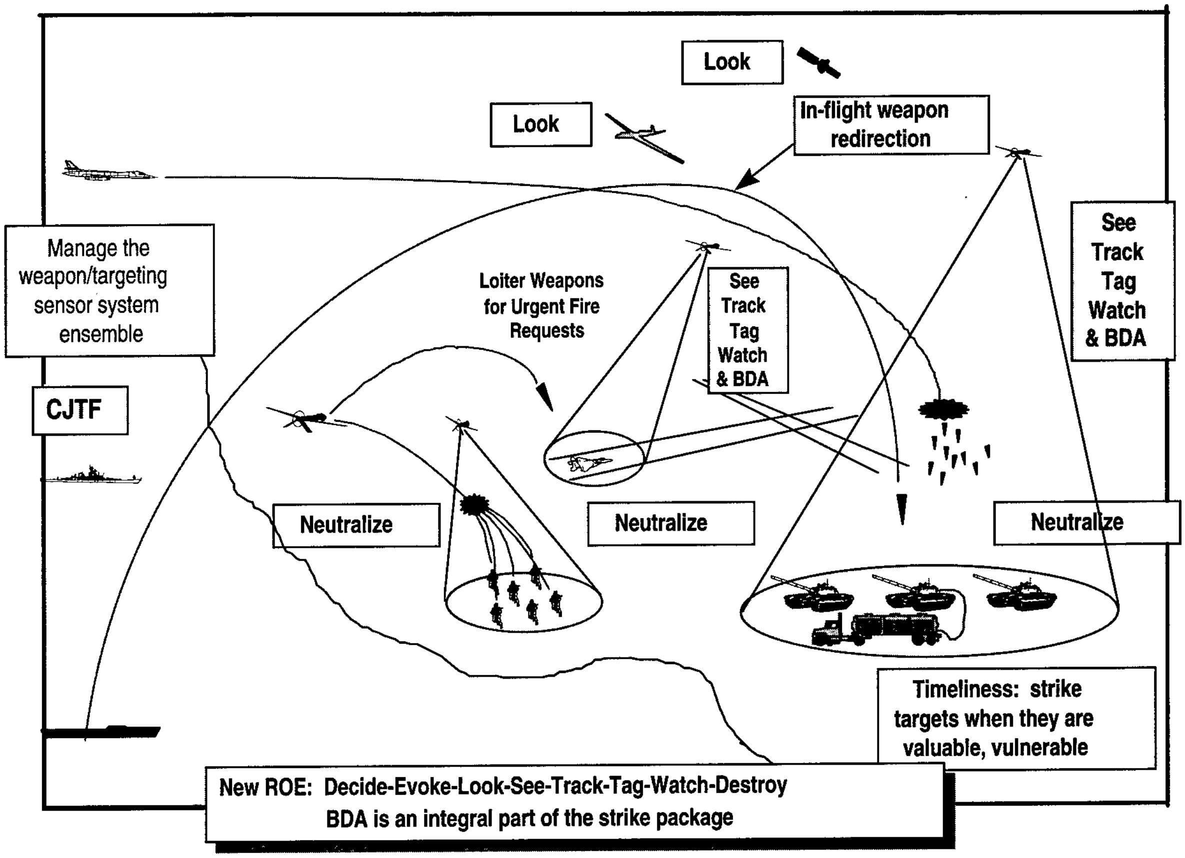


Figure X–2. Leveraging Precision Remote Fires—Force Projection/Dominant Maneuver

context of the "bigger picture." This capability, enabled by a common digital datalink, will provide an overall warfighting capability greater than the sum of the individual abilities of the individual force members.

- *Effective Battle Management, Command, and Control*—the capability of the commander to act effectively on his situation understanding, by directing the actions of subordinate and supporting forces, within the enemy's decision cycle.
- *Responsive, Remote Fires*—the timely, assured availability of mission-appropriate, cost-effective weapons and precision munitions to implement the commander's intent. Remote fires will be delivered mainly by long-range guns and missiles—launched from ground-, air-, or sea-based platforms, bombers, sea-based aircraft, and land-based tactical aircraft (if bases are available in theater). These fires will be responsive to changes in the flow of battle. Shorter time-of-flight weapons and munitions will not, by themselves, provide the requisite responsiveness. Consequently, incoming weapons and munitions will be "retargetable" in flight. There will also be important roles for loitering weapons.
- *Robust Information Infrastructure*—the capability to provide comprehensive, tailored information to distributed, potentially mobile subscribers, when and where required, regardless of the operational environment, through a secure, multitiered communications network. The information infrastructure is rapidly deployable, survivable,

scaleable, flexible, and reconfigurable to mission requirements. Its principal functions are (1) facilitating comprehensive situation understanding and effective battle management, command, and control; and (2) ensuring responsive remote fires. Among the many attributes required to do so are the provision of positive position (temporal and spatial) location (and thus identification) of subordinate and supporting units and of enemy units. Among its ancillary functions is the provision of telemedicine services. The secure, multitiered communications network will make use of geosynchronous and low-earth-orbit satellites, aircraft, and unmanned aerial vehicles. This enables it to be rapidly deployed and to function in a theater of operations lacking developed information infrastructures (commercial or military).

- *Assured Mobility*—the capability to rapidly place the force or elements of the force and requisite materiel where they need to be, when they need to be there, in order to execute the commander's concept and intent. This requires the capability to address the mine threat effectively.
- *Smart Sustainment*—the capability to apply smart logistics techniques using the information infrastructure to provide the right materiel at the right place and time with a vastly reduced logistics footprint and many fewer logistics personnel in the combat zone.

2. Joint Countermine

Historically, countermine operations, both at sea and on land, have been considered in terms of a number of elements, individually and separately applied to various mine search and neutralization tasks in different environments. The objective of Joint Countermine is to address the complex countermine problem through a "system-of-systems" approach. This approach will integrate all equipment and operations into a seamless capability to conduct joint land and littoral warfare, including amphibious or land/airborne missions into hostile territory with minimal disruption and losses due to minefields. This seamless countermine capability will also significantly enhance the capability to safely maneuver forces in regional engagement/presence missions.

The diverse service countermine elements will be integrated through a common communication architecture that will provide commanders full visibility, status, and control of countermine operations. The Joint Countermine Operational Simulation (JCOS) will permit realistic staff training, mission rehearsal, and, ultimately, operational support at all operational unit echelons.

In nearly all Joint Warfighting Capability Assessment (JWCA) mission areas, mines (sea and land) offer a potential adversary a low-cost means of denying our forces choice of maneuver options, particularly in view of America's low tolerance for combat losses. The best way to counter mines is to detect their presence and avoid them. However, even with "perfect" real-time intelligence, this may not always be feasible. Minefields are generally employed to shape the battlespace, channeling the opposition's forces in the direction that the enemy desires. In such a situation, circumventing a minefield may be playing into the enemy's hands. Consequently, breaching may become necessary to sustain maneuver. Regardless, the decision as to where, how, and when to enter a combat area must be made with the maximum confidence in our knowledge of the location and nature of the mine threat.

The first essential step in Joint Countermine is broad, clandestine, and low-observable surveillance using all available sources, including national technical means (NTM) and human

intelligence (HUMINT), to characterize battlespace and to narrow maneuver options. This initial surveillance phase is followed by tactical clandestine reconnaissance using a wide variety of sensors and platforms, including unmanned aerial and underwater vehicles (UAVs/UUVs), for detailed investigation of potential avenues of approach in the presence of mines, obstacles, and other defenses. The commander selects the actual assault path based on the latest intelligence and, once overt operations commence, seeks to establish a beachhead or lodgment within 2 to 6 hours of committing forces. Even in areas deemed to contain few or no mines, some breaching operations must be anticipated, since mines could be emplaced at the last minute or scattered into the area by aircraft, missiles, and artillery.

Figure X–3 shows an integrated operational concept that relies on highly effective surveillance, reconnaissance, detection, characterization, and breaching or clearance of mine and obstacle fields to ensure force mobility in hostile areas. The individual systems used to implement this concept must provide the high confidence necessary to make reliable judgments concerning the likelihood of success and potential losses associated with various maneuver alternatives. The objective of countermine S&T programs is to have, by the year 2001, an initial limited capability to counter the most serious current countermine deficiencies and, by 2006, a demonstrated technical capability to address all currently known threats.

The initial 5-year capability will be achieved through a combination of countermine systems integrated into a common joint command and control structure. Data collected by NTM will be made available in near-real time to tactical commanders. Individual elements of the S&T program are developing a variety of multispectral sensor systems for employment on remotely controlled UAVs and UUVs to detect minefields at sea, in the surf zone, on the beach, and on land. Several DTAP DTOs complement these S&T elements: SE.33.01, Advanced Focal Plane Array Technology;

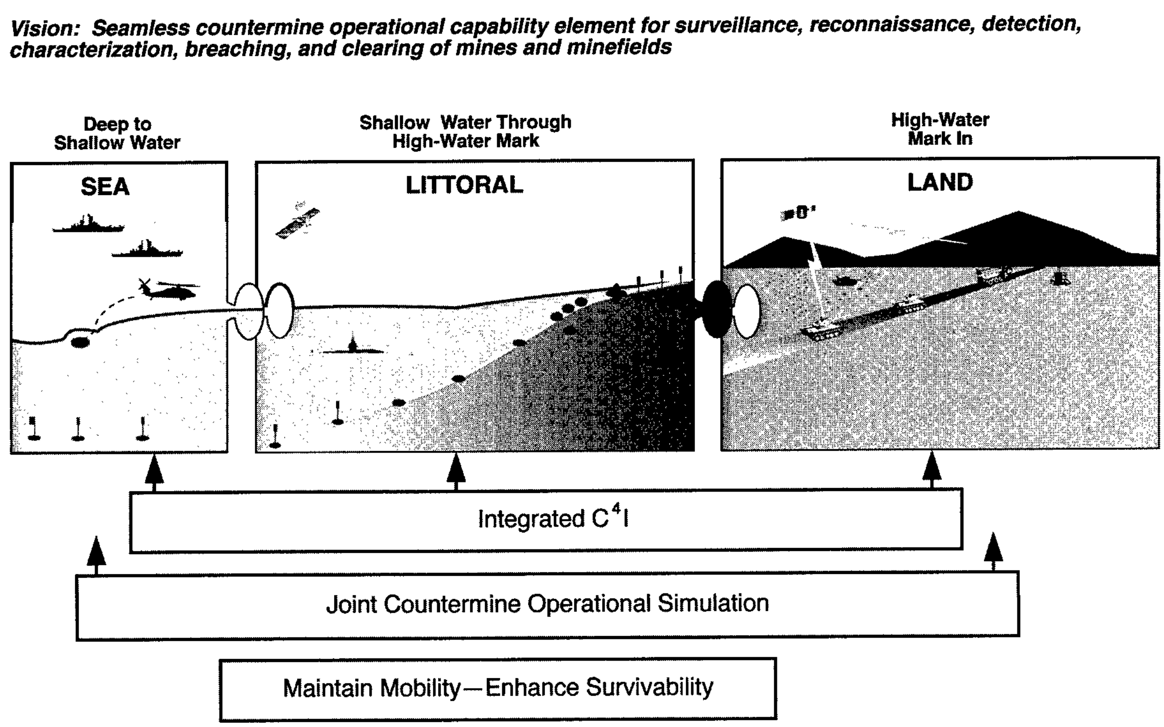


Figure X–3. Concept—Joint Countermine

SE.28.01, Low-Power Radio Frequency Electronics; and SE.29.01, Design Technology for Radio Frequency Front Ends. Sensors for mine/minefield detection include multibeam sonars for high-rate underwater search; ultrasensitive magnetic sensors and synthetic aperture sonars for buried sea mine detection; ground-penetrating radar for nonmetallic targets; and multispectral, hyperspectral, forward-looking radar and infrared imaging for detection of mines and minefields on the beach and on land. Through the use of these sensors, the program will demonstrate the detection of volume and bottom sea mines, buried land and sea mines, and roadbed antipersonnel mines, including plastic mines, at greater than 95 percent probability of detection and acceptable false alarm rates. Breaching and clearing of surf, beach, and land areas will be accomplished by advanced mechanical, electronic, and explosive systems currently in development.

Longer term (10-year) capabilities depend on advanced technologies now emerging from basic and applied research. These will form the basis for joint countermine forces to keep pace with the anticipated expansion of the sea and land mine threat well into the 21st century. Promising longer term technologies being pursued include directed-energy and underwater focused-pressure shock waves for mine destruction; hypersonic, water-piercing projectiles for standoff sea mine clearance; undersea acoustic local area networks and chemical sensing for underwater mine detection; and improved laser imaging and advanced synthetic aperture radar for clandestine reconnaissance and detection.

C. FUNCTIONAL CAPABILITIES

1. Projection and Maneuver Dominance

Achievement of Force Projection/Dominant Maneuver depends largely on the realization of many of the specific functional capabilities associated with the JWCOs of Information Superiority and Precision Force. The six principal Force Projection/Dominant Maneuver operational capability elements are enabled by the functional capabilities described below.

Comprehensive situation understanding can be described in terms of information acquisition and consistent battlespace visualization. *Information acquisition* is the provision of sufficient, timely, and high-quality surveillance, reporting, target designation, and assessment information on enemy, friendly, and U.S. units (including their location, activities, status, capabilities, plans, and intentions) to ensure that joint or coalition commanders have dominant battlespace knowledge. This requires the capability to predictively task the required resources in real time to acquire, correlate, fuse, sort, and distribute relevant data—derived from tactical and supporting C^4ISR resources for targeting, weapon selection and delivery planning, mission preview, battle damage assessment, and combat assessment—in order to enable the commander to exploit and shape the battlespace. *Consistent battlespace visualization* is the capability to take that battlespace knowledge and turn it into cognitive understanding of enemy and friendly units' locations, status, and actions and the surrounding environment (e.g., weather, terrain (natural and manmade), location of noncombatants, location of mines and obstacles, etc.), and to maintain consistency in that view across tactical and supporting forces. Gaining this consistent battlespace visualization further allows the commander to dedicate the best forces to each situation to maximize his forces' ability to achieve the objectives he has set.

Exploiting that understanding requires *effective battle management, command, and control.* This in turn requires predictive mission planning and rehearsal and integrated force management.

Predictive mission planning and rehearsal encompasses the set of capabilities required to be proactive in the planning process in order to shape expected actions to stay within an enemy's decision cycle and keep him out of ours. This includes the ability to conduct real-time collaborative planning and assessment across joint and potentially coalition forces. *Integrated force management* is that set of capabilities needed to synchronize the missions and resources of force components and coalition forces to achieve the commander's intent. This includes the capability to provide processing languages, interface characteristics, and linkages that enable rapid target search and acquisition, battle coordination and target selection, handoff, and engagement for the prosecution of time-critical targets, particularly with remote fires.

Responsive remote fires require selection of the optimum weapons and the timely, precise engagement of designated targets with those weapons. *Optimum weapon selection* is that set of capabilities needed to find and select the appropriate weapon(s) in terms of desired munitions effects on target (including considerations of limiting collateral effects), accuracy, and time of flight to effectively execute the commander's intent. *Precision engagement* can be thought of in terms of the ability to direct selected munitions to engage targets precisely when and where the commander's concept dictates they must be engaged.

Comprehensive situation understanding, effective battle management, command and control, and the provision of responsive remote fires depend very much on a *robust information infrastructure*. This infrastructure must provide *universal transaction information services*—the ability of warfighters and their systems to exchange and understand information, unimpeded by differences in connectivity, on a "just-in-time" basis, regardless of location (including urban terrain) or weapon system. It must also *support operations in a distributed environment.* That is to say, it must provide the mechanisms and services required to allow the warfighters to tailor their C^4ISR information environments from the full set of available assets (in and out of theater), including the ability to establish distributed virtual staffs and task teams. Finally, it must provide *high assurance information system services*—those high-quality services with built-in self-protection features that warfighters must have, when needed, to meet dynamically changing demands and defend against physical and information warfare threats. This includes adaptive network management that anticipates changing requirements, and the defensive information warfare (IW) operational capabilities of information security, operations security, information integrity, attack detection, and restoration. It must also be rapidly deployable to, and function in, a theater of operations with a minimal communications infrastructure and minimal human operator requirements

Assured mobility addresses inter- and intra-theater mobility as well as tactical mobility. It is the capability to insert and extract a force from an area of operations and the ability of that force to move tactically about that area at will. *Assured force insertion and extraction* requires survivable, unobtrusive means of inserting and extracting the force (or selected elements of the force) and its equipment. *Tactical mobility* requires a survivable means of providing the elements of the force in an area of operations the ability to rapidly move themselves and their materiel, across all types of terrain, in all types of weather, to the location where they need to be, when they need to be there (e.g., for purposes of observation and engagement, to rapidly coalesce in response to one type of threat, or to disperse in response to another). *Assured mobility* requires the capability to address the mine threat effectively.

Once in their area of operations, the force must be sustained. There are two elements to *smart sustainment.* The first is *near-real-time force asset visibility and assessment*—a continuous

awareness of the readiness status of elements of the force and supporting forces, cognitive understanding of the affect of that status on ongoing and planned operations as well as the likely effect of operations on those forces' readiness, and a precise knowledge of the location and timed availability of the supplies and services required to maintain the requisite readiness. This includes the ability to continuously monitor the location and status of supplies and services in the logistics pipeline. Smart sustainment also requires *on-time delivery* of requisite materials and services—that is, the ability to ensure their delivery at the appropriate time and location to maintain unit readiness in accordance with the commander's concept and intent. This requires timely, efficient, and effective control of the logistics pipeline. This in turn involves predictive determination of the time sequencing of requisite supplies and services, timely sourcing and ordering of the requisite supplies and services, selection of appropriate modes of transportation to ensure timely delivery, and redirection/rerouting to accommodate changes in the situation.

Table X–1 provides a mapping of the Force Projection/Dominant Maneuver functional capabilities to the operational capability elements and broad operational capabilities.

Table X–1. Functional Capabilities Needed—Force Projection/Dominant Maneuver

	Operational Capability Elements					
Functional Capabilities	Comprehensive Situation Understanding	Effective Battle Management, Command, and Control	Responsive Remote Fires	Robust Information Infrastructure	Assured Mobility	Smart Sustainment
1. Information Acquisition	●	○	○		○	○
2. Consistent Battlespace Visualization	●	○	○		○	○
3. Predictive Mission Planning and Rehearsal		●	○		○	○
4. Integrated Force Management		●	○		○	○
5. Optimum Weapon Selection			●			○
6. Precision Engagement			●			○
7. Universal Transaction Information System Services	●	●	●	●	●	●
8. Distributed Environment Information System Support	●	●	●	●	●	●
9. High-Assurance Information System's Services	●	●	●	●	●	●
10. Assured Force Insertion and Extraction					●	○
11. Tactical Mobility					●	○
12. Near-Real-Time Force Asset Visibility and Assessment	○	○	○			●
13. On-Time Delivery of Logistics Services					○	●

● Strong Support ○ Moderate Support

2. Joint Countermine

Table X–2 illustrates the joint countermine functions required to produce the operational capability elements.

Table X–2. Functional Capabilities Needed—Joint Countermine

	Operational Capability Elements									
	Surveillance, Reconnaissance, and Detection			Breaching and Neutralization		Battlespace Management				
Functional Capabilities	Continuous Surveillance	High-Rate Area Reconnaissance/ Detection	Precision Mine Location	Route Clearance, Sweeping, and Breaching	Area Clearance	Avoidance	Marking	Reporting	Recording	Dissemination
1. All-Source Intelligence Fusion	●	●	○	○	○			○	○	○
2. Environmental Characterization	●	●	●	○	○					
3. Minefield Detection	●	●	○	○	○					
4. Individual Mine Detection		●	●	○	○					
5. Mine Classification		●	●	○	○					
6. Mine Identification		●	●	○	○					
7. Low-Cost Robotics	○	●	●	●	●					
8. Signal Processing and Sensor Fusion		●	●							
9. Mine Removal/Destruction				●	●					
10. Obstacle Removal				●	●					
11. Common C^4I Environment						●	●	●	●	●
12. High-Data-Rate Communications						●	●	●	●	●
13. Signature Reduction						●				
14. Vulnerability Reduction						●				

● Strong Support ○ Moderate Support

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

1. Projection and Maneuver Dominance

Capabilities and deficiencies can be defined to a large extent in terms of the military capabilities an adversary can bring to bear against our forces. In the *Concept for Future Joint Operations* (Reference 20), the Joint Chiefs of Staff identify a number of potential "asymmetric counters"—military capabilities that adversaries may develop and deploy to offset the United States' conventional superiority. Of particular importance for accomplishment of Force Projection/Dominant Maneuver objectives are those asymmetric counters that are likely to be relatively more effective against the United States and relatively easier for adversaries to develop, deploy, and employ, including:

- Mines
- Offensive information warfare
- Cheap, survivable missiles with camouflage, concealment, and deception (CC&D)
- Cheap, survivable missiles with CC&D and weapons of mass destruction (WMD) payloads.

Key potential vulnerabilities, which cut across the operational capability elements, involve:

- Use of offensive information warfare and WMD effects (notably, the electromagnetic and radiation environments produced by nuclear weapons) to deny the information superiority that is required for achievement of Force Projection/Dominant Maneuver.
- Utilization of WMD against the small numbers of critical nodes, notably high-capability ports and airfields, that are likely to be critical in many contingencies.
- Use of WMD, particularly WMD delivered by missiles, against military systems involved in Force Projection/Dominant Maneuver operations. Systems at potential risk include weapon platforms, C^4I, and massed forces.
- Employment of mines to impede or prevent access and maneuver.

Arguably, the most crucial barrier to implementation of Force Projection/Dominant Maneuver is in the area of information systems. Fielded information systems do not provide the kind of robust, assured, and timely flow of accurate and relevant information required for comprehensive situation understanding, effective battle management, command and control, or the provision of responsive remote fires. The C^4ISR structure is rigid and is generally divided along organizational and functional lines. This "stovepiping" makes it difficult to acquire, process, and disseminate essential information across joint and potential coalition forces in a timely manner, making it exceedingly difficult to develop a comprehensive situation understanding. The lack of a comprehensive, common picture of the battlespace complicates battle management, command, and control, making effective tasking and synchronization of forces and selection and direction of remote fires difficult, particularly against mobile or fleeting targets, which may require in-flight retargeting. Additionally, current C^4ISR systems provide only a limited ability to detect and monitor targets and events concealed in foliage, in structures, or in adverse weather or countermeasure environments. Further complicating targeting, current information systems do not support assured combat identification, particularly across joint and coalition forces. Rigid intelligence, surveillance, and reconnaissance (ISR) systems and a lack of visibility of independent tactical sensor tasking and coverage further limit the ability to manage and coordinate sensor assets for timely operations and responsive remote fires. In addition, there is only a limited ability to develop a common picture of the battlespace that is accessible at multilevels of security—particularly crucial in a coalition environment. Current systems are not rapidly deployable in a theater that lacks an extensive, modern information system infrastructure, and are manpower intensive. Their ability to operate in urban environments is hindered by the effect of manmade structures on communications systems. Finally, current systems do not provide the requisite assurance of delivery of information in a countermeasures environment.

The limitations of fielded information systems also affect smart sustainment. Field information systems provide a less than satisfactory ability to monitor and assess the status of organic and

supporting forces, minimal visibility into the logistic pipeline, and a limited ability to redirect the flow of materiel in that pipeline.

Perhaps the greatest threat to assured insertion and extraction of forces are weapons of mass destruction (chemical and biological agents being perhaps of the most concern), particularly when delivered by missiles. Although there is some capability to intercept ballistic missiles, there is only a limited capability to detect, track, and intercept cruise missiles. Sea mines and mines in the surf zone also affect the ability to insert and extract forces, while landmines affect tactical mobility in theater. Current operational countermine surveillance capabilities are extremely limited. The wide variety in mine designs and the different environments in which mines are employed preclude a single, simple solution. Further, the Navy's mine detection capabilities are best suited for deep-water operations, rather than the littoral environment in which our contingency forces are most likely to be employed. Table X–3 provides a mapping of key technologies to limitations and functional capabilities for each of the six operational capability elements.

**Table X–3. Goals, Limitations, and Technologies—
Force Projection/Dominant Maneuver**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Comprehensive Situation Understanding			
Provide a timely, comprehensive, and consistent view of the battlespace and a cognitive understanding of the present and future implications of the information derived from that view on the ability of the force to execute the commander's concept and intent.	Information acquisition • Survivable, full spectrum, day/night, all-weather sensors • Sensor correlation and fusion • Timely sensor retasking Consistent battlespace visualization • Intelligence processing and broadcast (theater wide) • Rapid, accurate battle damage assessment • Positive combat ID • Intelligence preparation of the battlefield (IPB) • Situation projection • LO UAV for surveillance	Sensor limitations • Foliage • Urban terrain • Weather • Countermeasures • Relocatable targets • Discrimination — Civilians — Friendly forces • Limited real-time retasking capability Information systems "stovepiping" along functional area boundaries Compartmentation of information Lack of automation • Integration/fusion and broadcast • Target ID • BDA • Retasking • IPB • Cost/accuracy of remote sensor delivery systems	Robust, layered, and integrated, multispectral, autonomous (smart) sensors (fixed and retaskable mobile sensors) Software to automate information processing and broadcast, target ID, BDA sensor retasking, and the IPB process across functional area boundaries Joint (combined) multisensor fusion, information fusion, and sensor cross-cueing Common platforms and applications Multilevel information security Precision airdrop

Table X–3. Goals, Limitations, and Technologies— Force Projection/Dominant Maneuver (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Effective Battle Management, Command and Control			
Provide the commander the ability to utilize his comprehensive situation understanding to effectively direct the actions of his subordinate and supporting forces within the enemy's decision cycle.	Predictive mission planning and rehearsal • Timely, distributed collaborative planning and rehearsal Integrated force management • Universal dissemination and understanding of the commander's concept and intent • Rapid accurate target acquisition and engagement — Effective prosecution of time-critical targets with remote fires	"Stovepiping" Compartmentation of information Lack of automation Automated systems not dynamic	Software and systems to automate mission planning and rehearsal (virtual staffs) process and to provide it a capability to adjust to changes in tactical situation in real time Intelligent agent software for knowledge retrieval, filtering, sanitization, and deconfliction Common platforms and applications Advanced modeling and simulation tools
Operational Capability Element: Responsive, Remote Fires			
Provide assured, effective fires in a timely manner to implement the commander's intent.	Optimum weapon selection • Timely identification and selection of appropriate weapons for effective target prosecution Precision engagement • Ability to direct selected munitions for effective target prosecution	"Stovepiping" Lack of automation Difficulty in engaging relocatable targets Sensor environmental limitations • Vegetation • Urban terrain No conventional chemical/biological agent defeat payloads	Software and systems to provide autonomous force status tracking Software and systems to provide automatic weapons and target pairing and engagement Multispectral sensors Autonomous loitering weapons • Onboard ATR, BDA, and retargeting capability Conventional weapons to defeat chemical/biological agent processing and storage facilities
Operational Capability Element: Robust Information Infrastructure			
Provide the rapidly deployable, assured information services required to enable comprehensive situation understanding, effective battle management, command and control, responsive remote fires, and smart sustainment	Universal transaction information system services Distributed environment information system support High-assurance information system services	Environmental degradation of service • Urban terrain Deployability Survivability Coverage, quality, and currency Lack of automation	Robust, reconfigurable survivable cellular information infrastructure • Automated information processing/management • Direct and selective broadcast — Information tailored to subscriber — Managed by intelligent agents — Multilevel security/access • Subscriber digital link • Survivable air communications and information processing platforms for theater-wide data transport • Uplinks to satellites for global transport • Spatial/temporal location of subscribers and targets • Transparent (to the user) integration of legacy systems

**Table X–3. Goals, Limitations, and Technologies—
Force Projection/Dominant Maneuver (continued)**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Assured Mobility			
Provide the assured capability to rapidly place the force or elements of the force and requisite materiel where they need to be, when they need to be there, in order to execute the commander's concept and intent.	Assured force insertion and extraction • Survivable, unobtrusive means of intra- and inter-theater transport Tactical mobility • Survivable all-weather and terrain transport	Limited capability to counter cruise missile threat Limited capability to detect and neutralize mines All-weather, clandestine, precise combat insertion	Systems and software providing comprehensive situation understanding Improved systems to detect and breach minefield in stride Improved systems to detect and counter cruise missiles Precise airborne insertion
Operational Capability Element: Smart Sustainment			
Provide the assured capability to provide the right materiels and services at the right place and time to effectively implement the commander's intent.	Near-real-time force asset visibility and assessment • Continuous awareness of force readiness status and the effects of ongoing and planned actions on readiness On-time delivery of logistics services	"Stovepiping" • Limited collaborative planning • Limited ability to monitor status across organizational boundaries Limited visibility into logistics pipeline Limited ability to redirect logistics flow in pipeline Limited ability to monitor status of organic and supporting elements Lack of automation	Software and systems to automate planning and asset tracking process (virtual staffs) and to provide ability to predictively assess unit and weapon status and redirect logistics flow as required

2. Joint Countermine

Table X–4 presents the technologies needed to breach the limitations on achieving the joint countermine objective. Current operational countermine surveillance capabilities are extremely limited. With the exception of mine reconnaissance by Special Operations Forces, very few dedicated collection systems exist. Exploitation of NTM for countermine intelligence is limited by the absence of tailored countermine products and less than adequate C^4I capabilities and procedures for information distribution to operational commanders and forces. Mine-related databases are sparsely populated, and prediction/forecasting models are often not validated. Services now rely on overt tactical techniques to acquire and detect mines.

The Navy's mine detection capabilities are limited to dedicated mine countermeasures (MCM) ships and aircraft equipped with systems designed primarily for deep water or friendly port breakout missions. These systems have limited capabilities in the very shallow waters of the littoral, and the specialized platforms can require long lead times to reach a crisis response area. Organic mine reconnaissance systems for use by non-MCM surface ships and submarines are just beginning to be fielded. Detection of mines in very shallow water and in the surf zone is slow and limited to Navy SEALs using handheld equipment or marine mammals (not surf zone capable).

Table X–4. Goals, Limitations, and Technologies—Joint Countermine

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Surveillance, Reconnaissance, and Detection			
Collect, correlate, and report prehostility mining operation; after mines are laid, provide commanders and individual units and soldiers the ability to detect and avoid mines/minefields from a safe distance at maneuver speed.	All-source intelligence fusion	Information from various national, theater, and tactical sensors not fully compatible No ability to provide continuous countermine surveillance Limited access to intelligence databases at tactical level	Exploitation of NTM for countermine purposes GCCS-compatible tactical decision aids and mission planning tools Automated sensor/processor C^4I interfaces
	Environmental characterization	Limited high-search-rate capabilities Limited littoral environmental data	Autonomous ocean sampling for littoral marine environment
	Minefield detection	Limited ability to determine precise minefield boundaries Limited ability to distinguish minefields from background clutter Limited sensor ranges and high false alarm rates Limited clandestine sensors for very shallow water, surf zone, and land Limited high-search-rate capabilities	Autonomous/remotely operated air vehicles Multispectral/hyperspectral imaging Enhanced IR sensitivity and resolution Multispectral image processing Automatic target pattern recognition IR polarization Multisensor fusion Multibeam volume search sonar Synthetic aperture radar and sonar
	Individual mine detection Mine classification Mine identification	Limited endurance of autonomous vehicles Limited capability to detect buried mines in high-clutter background Limited capability to identify mines in very shallow water, in surf zone, and on land	Autonomous/remotely operated vehicles Forward looking radar/IR Low-cost robotic platforms Efficient power generation Superconducting magnetic gradiometers Ground penetrating radar/IR High-repetition-rate laser imaging technologies Streak Tube Imaging LIDAR (STIL) ATR algorithm enhancements
	Signal processing and sensor fusion	Limited capability to co-register multiple dissimilar sensor inputs	Enhanced signal processing algorithms for co-registration

Table X–4. Goals, Limitations, and Technologies—Joint Countermine (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Breaching and Neutralization			
From the sea to land combat—dispose of mines in deep, shallow, and very shallow water through the craft landing zone into the land with minimal casualties to men and equipment.	Mine removal/destruction Obstacle removal	Slow, dangerous, labor-intensive mine neutralization Limited ability to breach and clear minefields in a timely and safe manner No capability to sweep pressure influence sea mines Limited capability to neutralize mines on land, in surf, and in shallow water	Robotic breaching, neutralization, and removal systems Enhanced efficiency of power generation and reduced weight for magnetic and seismic influenced sweeping sources Focused pressure shock waves Enhanced explosive materials Increased standoff explosive neutralization techniques Hypervelocity projectiles Kinetic energy neutralization RF signal neutralization Chemical neutralization
Operational Capability Element: Countermine Battlespace Management			
Provide synchronized countermine command and control in support of joint operations.	Common C^4I environment	Information from various national, theater, and tactical sensors not fully compatible Limited access to intelligence databases at tactical level Common countermine operational picture not available Optimum mission planning and equipment design not supported by models and data C^4I systems and computer models supporting countermine not fully compatible Limited ability for automated marking of mines/minefield data to situation displays	Interactive distributed simulation models
	High-data-rate communications	Capabilities of autonomous/remotely operated systems limited by communication data rates	Data compression, bandwidth optimization, and high-data-rate acoustic modems
	Signature reduction Vulnerability reduction	Naval vessels/ground vehicles vulnerable to influence mines due to their magnetic signatures	Closed-loop degaussing and active magnetic field suppression

Likewise, land forces rely on fragmentary intelligence for the locations of mine and minefields. A primary source continues to be HUMINT via interviews with the local populace and the use of scouts and patrols to conduct visual reconnaissance missions. A computer database of mine properties is available to ground forces. The detection of individual mines by land forces is still conducted much as it was during World War II using handheld magnetic detectors or probes.

Significant technological barriers exist in the detection of mines. The wide variety in mine designs (metallic/nonmetallic, contact/influence fuzed) and the different environments in which mines are employed (sea, surf, beach, land) preclude a single solution approach to the detection

problem. Ultimately, the challenge is to detect and identify mines and minefields in high background clutter with a low false alarm rate. Several mine designs and environments provide unique challenges. In both the maritime and land environment, buried nonmetallic mines are difficult to detect. Optical, magnetic, and acoustic sensors are of limited effectiveness in the high ambient noise of the surf zone. Surf and tides quickly erase mine burial scars on the beach—limiting the effectiveness of electro-optical systems. The land environment offers similar challenges for magnetic sensors, ground-penetrating radar, and passive infrared sensors. These challenges include soil type, moisture content, diurnal cycle, and natural and manmade ground clutter.

Mine breaching and neutralization are currently slow, tedious, and often dangerous. Sea mines are cleared either by influence or mechanical sweeping or through one-on-one neutralization charges. Mechanical sweeping of naval mines is conducted by dedicated MCM ships or aircraft and is only effective against moored mines in relatively deep water. Once swept, moored mines become "floaters" and are still dangerous. No rapid method for neutralizing these floaters exists, and they must be engaged one-on-one using small-arms fire or small explosive charges placed next to the mines by a tethered robotic mine neutralization system (MNS) or by explosive ordnance demolition (EOD) personnel. Bottom magnetic or seismic influence mines are swept using influence sweeping devices deployed from MCM ships or helicopters. The United States has no capability to sweep pressure influence mines; the only method for neutralizing these mines is to first locate and then disable them using an explosive charge placed by the MNS or by EOD safe rendering procedures.

Current surf zone, beach zone, and land mine clearance is limited to M–58 and M–59 line charges deployed from autonomous armored vehicles or trailers accompanied by the Track Width Mine Plow (TWMP) for proofing. Explosive line charges generate overpressure onto a minefield. Current mechanical neutralization and breaching techniques simply push mines into the plowed spoil. In both cases, there is no standoff capability. The overall effectiveness of these systems is further hampered by technological enhancements to mine fuses and the environmental limitations imposed on each of the neutralization techniques.

Reliable neutralization of mines presents several unique challenges. Improved targeting systems and in-depth ballistic/hydroballistic analysis and testing are needed to make directed fire an effective neutralization tool against subsurface or buried mines. A technology breakthrough is required to solve the naval pressure minesweeping problem. To reduce human vulnerability, neutralization techniques like signature duplication must be light enough to be deployed from small, remotely controlled vessels and ground systems and be highly durable to operate in the high shock/vibration conditions of the surf and land battlefield environments. Breaching operations are complicated by mines and obstacles deployed together. The effectiveness of explosive line charges, vehicle signature projection systems, and Track Width Mine Plows/Track Width Mine Rollers (TWMP/TWMR) is significantly degraded when obstacles are factored into the countermine task.

To provide a true in-stride breaching capability, improved fire control systems must be developed to permit the firing of breaching charges during amphibious landing craft operations in breaking surf and from vehicles on the run. Improved breaching charges must be developed to provide a high kill probability against all types of fuzed mines, including those buried by surf and tidal action on the beach. Additionally, for a holistic breaching capability, efforts are needed in the area of obstacle removal.

Another new challenge to land warfare is off-route mines. This emerging threat can lay in wait at standoffs up to 100 meters, and it is capable of targeting and killing mechanized forces without being detected. Systems must be developed for in-stride clearance of these mines from the shoulders of the intended route as well as from barrier minefields.

Area clearance in support of a military mission is a challenge that has been overlooked. This task requires the clearing of large areas infested with mines or unexploded ordnance (UXO). Such an action is paramount to the conduct of logistics over the shore and the establishment of rear-area Combat Service Support (CSS) functions. CSS elements must be capable of operating in a mined environment. Currently these units rely on many of the same personnel and equipment resources that support the maneuver force. Clearance resources available to the CSS as well as to the general forces are limited and labor intensive. Efforts are needed to provide mechanical, electronic, robotics, and low-order neutralization technologies that will allow for the systematic removal of mines and UXO by organic resources. Dissemination of intelligence relative to the locations of previous combat and fire support operations is required. This intelligence will allow CSS units operating in post-combat areas to be aware of the risk, and it will support planning for required clearance missions.

Battlespace management for countermine warfare must be improved. To be effective, the operational commander requires fused mine warfare intelligence in a timely manner within his overall maneuver battle plan. Currently, for both land and amphibious operations, the electronic dissemination of information regarding suspected minefields, actual mine locations, and cleared routes or areas is often inaccurate and unreliable. In shallow water, in surf zones, and on beaches, no capability exists to rapidly mark these areas cleared for follow-on maneuver. Mine warfare environmental sampling, databases, and modeling efforts must be improved if they are to contribute to the development of sensors and systems as well as real-time support for field commanders in the form of tactical decision aids (TDAs). Data collection tools for mine/minefield reports are needed to provide accurate, consistent mine data inputs. Software tools are needed to collect, store, format, display, and disseminate countermine data. The goal of this effort is to provide a comprehensive countermine picture to all required operational units. Reduction in the vulnerability of watercraft, land vehicles, and personnel to mines is a critical technical challenge involving blast deflection/absorption, signature duplication and projection, acoustic and magnetic signature reduction, and other techniques.

E. TECHNOLOGY PLAN

1. Projection and Maneuver Dominance

The science and technology program to correct the deficiencies in the operational capability elements—(1) comprehensive situation understanding, (2) effective battle management, command, and control, (3) responsive remote fires, (4) robust information infrastructure, (5) assured mobility, and (6) smart sustainment—is shown in Figure X–4. These technologies offer the potential for a significant increase in today's capabilities.

Table X–5 lists the Force Projection/Dominant Maneuver DTOs. Table X–6 maps the DTOs supporting Force Projection/Dominant Maneuver to the operational capability elements. The schedule for achieving these DTOs is depicted in the technology roadmap in Figure X–5. This roadmap addresses all six of the operational capability elements.

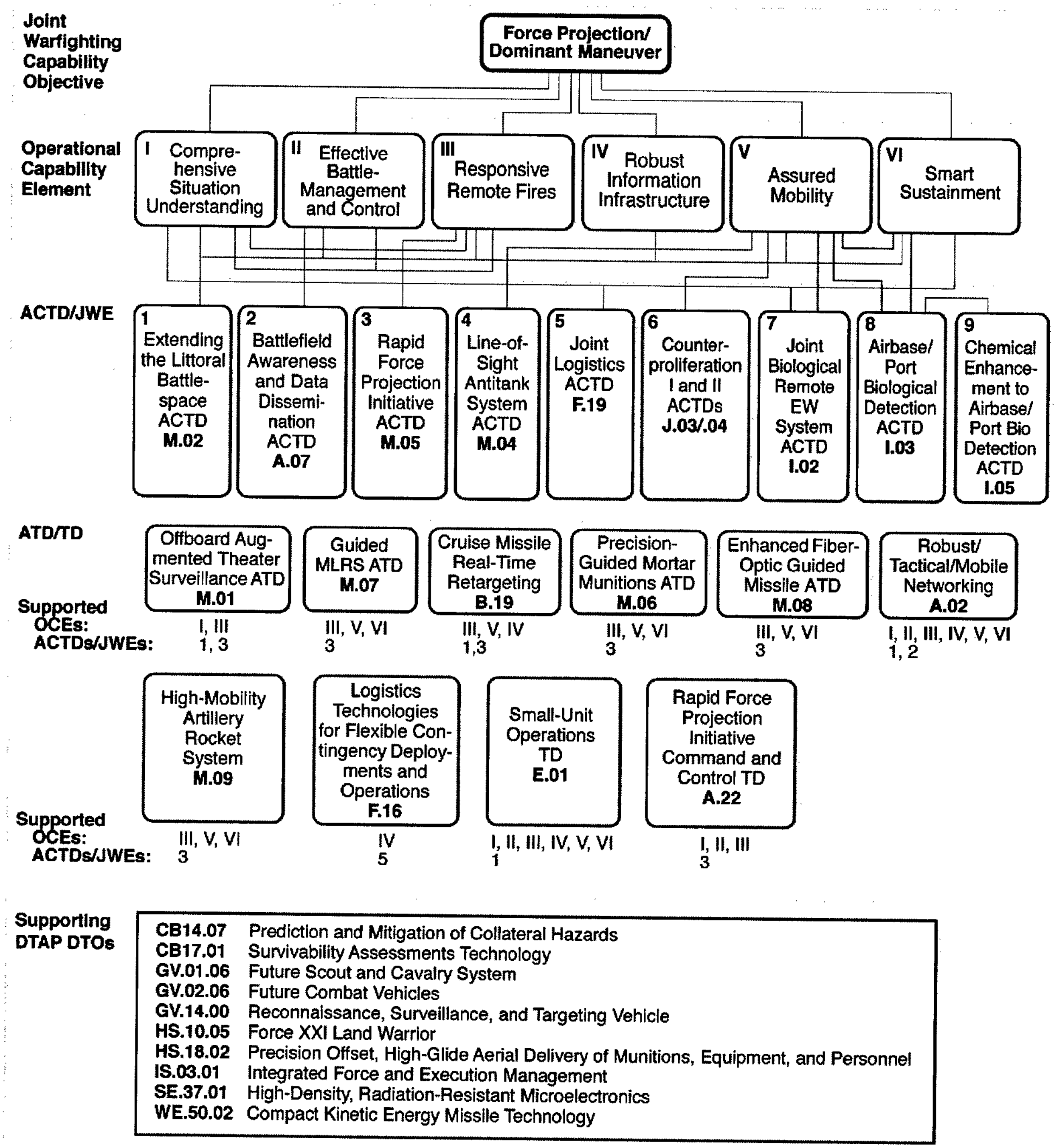


Figure X–4. Technology to Capability—Force Projection/Dominant Maneuver

Table X–5. Defense Technology Objectives—Force Projection/Dominant Maneuver

DTO No.	Title
M.01	Offboard Augmented Theater Surveillance ATD
M.02	Extending the Littoral Battlespace ACTD
M.04	Line-of-Sight Antitank System ACTD
M.05	Rapid Force Projection Initiative ACTD
M.06	Precision-Guided Mortar Munitions ATD
M.07	Guided MLRS ATD
M.08	Enhanced Fiber-Optic Guided Missile ATD
M.09	High-Mobility Artillery Rocket System
A.02	Robust/Tactical/Mobile Networking
A.07	Battlefield Awareness and Data Dissemination ACTD
A.22	Rapid Force Projection Initiative Command and Control TD
B.19	Cruise Missile Real-Time Retargeting
E.01	Small-Unit Operations TD
F.16	Logistics Technologies for Flexible Contingency Deployments and Operations
F.19	Joint Logistics ACTD
I.02	Joint Biological Remote Early Warning System ACTD
I.03	Airbase/Port Biological Detection ACTD
I.05	Chemical Enhancement to Airbase/Port Biodetection ACTD
J.03	Counterproliferation I ACTD
J.04	Counterproliferation II ACTD
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.17.01	Survivability Assessments Technology
GV.01.06	Future Scout and Cavalry System
GV.02.06	Future Combat Vehicles
GV.14.00	Reconnaissance, Surveillance, and Targeting Vehicle
HS.10.05	Force XXI Land Warrior
HS.18.02	Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel
IS.03.01	Integrated Force and Execution Management
SE.37.01	High-Density, Radiation-Resistant Microelectronics
WE.50.02	Compact Kinetic Energy Missile Technology

Table X–6. Demonstration Support—Force Projection/Dominant Maneuver

Demonstration	Operational Capability Elements: Comprehensive Situation Understanding	Effective Battle Management, Command, and Control	Responsive Remote Fires	Robust Information Infrastructure	Assured Mobility	Smart Sustainment	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Offboard Augmented Theater Surveillance ATD	●	○	●				Air Force	M.01		X
Extending the Littoral Battlespace	●	●	○	●	○	●	USMC	M.02	X	
Line-of-Sight Antitank System ACTD					●		Army	M.04	X	
Rapid Force Projection Initiative ACTD	●	●	●				Army	M.05	X	
Precision-Guided Mortar Munitions ATD			●		○		Army	M.06		X
Guided MLRS ATD			●		○		Army	M.07		X
Enhanced Fiber-Optic Guided Missile ATD			●		○		Army	M.08		X
High-Mobility Artillery Rocket System			●		○		Army	M.09		X
Robust/Tactical/Mobile Networking	○	○		●			Joint	A.02		X
Battlefield Awareness and Data Dissemination ACTD	●	●	○				DARPA	A.07	X	
Rapid Force Projection Initiative Command and Control TD	○	○	●				Army, Navy	A.22		
Cruise Missile Real-Time Retargeting			●		●		Navy	B.19		X
Small-Unit Operations TD	●	●	●	●	○	○	DARPA	E.01		
Logistics Technologies for Flexible Contingency Deployments and Operations		○			●	●	Air Force	F.16		
Joint Logistics ACTD	○					●	Joint	F.19	X	
Joint Biological Remote Early Warning System ACTD					●	●	Joint	I.02	X	
Airbase/Port Biological Detection ACTD					●	●	Joint	I.03	X	
Chemical Enhancement to Airbase/Port Biodetection ACTD					●	●	Joint	I.05	X	
Counterproliferation I ACTD	○		●		●		DSWA	J.03	X	
Counterproliferation II ACTD	○		●		●		DSWA	J.04	X	
Prediction and Mitigation of Collateral Hazards					●	●	Joint	CB.14.07		
Survivability Assessments Technology	●	●		●			Joint	CB.17.01		
Future Scout and Cavalry System	○	○	●		●		Army	GV.01.06		
Future Combat Vehicles			○		●		Army	GV.02.06		

● Strong Support ○ Moderate Support

Table X–6. Demonstration Support—Force Projection/Dominant Maneuver (continued)

Demonstration	Operational Capability Elements						Service/ Agency	Type of Demonstration		
	Comprehensive Situation Understanding	Effective Battle Management, Command, and Control	Responsive Remote Fires	Robust Information Infrastructure	Assured Mobility	Smart Sustainment		DTO	ACTD	ATD
Reconnaissance, Surveillance, and Targeting Vehicle	○	○	●		●		USMC, DARPA	GV.14.00		
Force XXI Land Warrior	●	●	●	●	○	○	Army	HS.10.05		
Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel	●				●	●	Army	HS.18.02		
Integrated Force and Execution Management	○	●	●				Army	IS.03.01		
High-Density, Radiation-Resistant Microelectronics	●	●		●			Joint	SE.37.01		
Compact Kinetic Energy Missile Technology					●		Army	WE.50.02		

● Strong Support ○ Moderate Support

Below is a description of how each DTO contributes to attaining the Force Projection/ Dominant Maneuver operational capability elements:

- *M.01, Offboard Augmented Theater Surveillance ATD,* will demonstrate capabilities, centered on the Joint Surveillance Target Attack Radar System (JSTARS), to fuse data from multiple sensors carried on a variety of platforms to cohesively detect, identify, and track dynamic time-critical targets in real time, greatly improving comprehensive situation understanding and precision engagement.

- *M.02, Extending the Littoral Battlespace ACTD,* will demonstrate an Extended Littoral Battlespace Combat Operations System that will enable commanders to dynamically control dispersed units, logistics, and fire so as to achieve a more adaptive, flexible and survivable Naval Expeditionary Force.

- *M.04, Line-of-Sight Antitank System (LOSAT) ACTD,* will develop and demonstrate a hypervelocity kinetic energy antitank weapon system that is designed to support early-entry force projection. It integrates the previously developed hypervelocity missile (HVM) with the High-Mobility Medium-Wheeled Vehicle (HMMWV) chassis and the Improved Bradley Acquisition System (IBAS). The LOSAT provides early-entry ground forces an overmatching capability to defeat armor at range, adding to their survivability and thus tactical mobility.

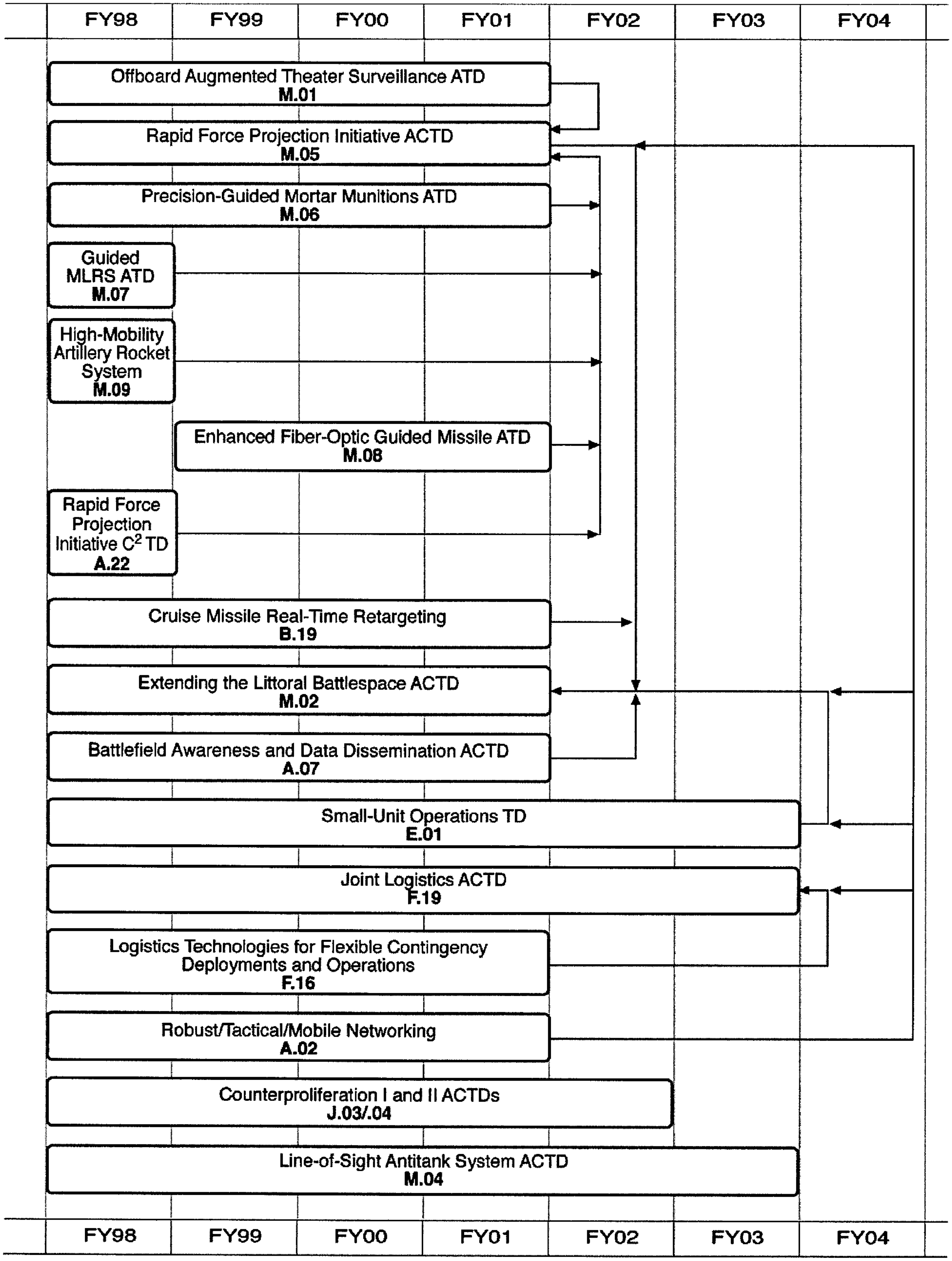


Figure X–5. Roadmap—Force Projection/Dominant Maneuver

- *M.05, Rapid Force Projection Initiative ACTD*, will demonstrate a highly lethal, survivable, rapidly deployable enhancement to an airlift-constrained early-entry task force. This concept integrates advanced sensors (hunters) and weapons (standoff killers) connected through a robust command, control, and communications (C^3) system, to provide a capability to detect, engage, and kill enemy armor and artillery forces at ranges beyond their ability to counter.
- *M.06, Precision-Guided Mortar Munitions ATD*, will demonstrate the ability to detect, engage, and defeat armored vehicles and high-value point targets such as earth and timber bunkers, command posts, and logistic sites, using precision guided 120-mm mortar munitions.
- *M.07, Guided MLRS ATD*, will demonstrate a guidance and control package that can be integrated with the M–270 Multiple Launch Rocket System (MLRS), bomblets, precision-guided submunitions, mines, and earth penetrator/unitary warheads. This DTO will provide technology for new types of precision weapon systems required to achieve Force Projection/Dominant Maneuver.
- *M.08, Enhanced Fiber-Optic Guided Missile ATD*, will demonstrate a precision standoff capability against high-priority ground and airborne (helicopter) targets under day, night, and adverse weather conditions out to a range of 15 km. This remotely directed missile system, with a gunner in the loop providing a manual real-time retargeting capability, can operate from defilade and engage targets in defilade, distinguish friend from foe, and thus reduce fratricide.
- *M.09, High-Mobility Artillery Rocket System*, will demonstrate a lightweight, C–130 transportable version of the M–270 MLRS that can fire any rocket or missile in the MLRS family, greatly enhancing the lethality of early-entry forces fire support.
- *A.02, Robust/Tactical/Mobile Networking*, will develop the technology to provide high-bandwidth, robust, multimedia, theater-level communications networking infrastructure that can be rapidly deployed to support military operation from the early-entry phases and throughout the lifetime of a conflict.
- *A.07, Battlefield Awareness and Data Dissemination (BADD) ACTD*, will integrate and demonstrate information management and battlefield awareness technologies that will allow operational users to easily access and exploit data from a multitude of disparate sensors. BADD will provide the capability for forward warfighters to access and utilize very large information products that were previously inaccessible to them and to seamlessly integrate these products with emerging 3D visualization applications. It will also provide the commander the ability to maintain battlefield awareness while on the move and to manage the information flow based on their operational needs.
- *A.22, Rapid Force Projection Initiative Command and Control TD*, will provide technologies for enhancing real-time decision making—to include in-flight threat updates, retargeting, rerouting, improved situation assessment, and semiautomated target transfer from forward sensors to weapon systems using C^3 integration—thus improving our ability to provide for precision engagements against a variety of high-priority targets.
- *B.19, Cruise Missile Real-Time Retargeting*, will provide technologies for brilliant, autonomous cruise missiles with onboard mission planning and control systems that can

provide precision aimpoint selection, battle damage indication, coordinated attack against fixed or mobile targets, and the ability to switch to alternate targets if the primary target has been destroyed by a previous strike.

- *E.01, Small-Unit Operations TD,* will demonstrate a capability to provide enhanced decision making at all echelons involved in MOUT operations, situation awareness for tactical-level combatants, tasking and control of multiple autonomous systems, and an advanced sensor capability that can detect, locate, and report targets and is dynamically linked with warfighter situation awareness and tasking capabilities so as to provide a flexible, precision targeting capability.
- *F.16, Logistics Technologies for Flexible Contingency Deployments and Operations,* will reduce logistics airlift requirements and footprints for deployed units and effect the transition of high-leverage technology tools to support flexible and rapid contingency deployments, the prediction of support asset requirements, and beddown operations at austere air fields.
- *F.19, Joint Logistics ACTD,* will develop interoperable joint logistics decision support tools and migrate existing tools to the Global Combat Support System (GCCS) and make those tools available via a web-based client server. This DTO provides the warfighter interoperable logistics decision support tools to reduce the logistics footprint, right-size inventories, and rapidly reprioritize and redirect combat support. It also provides a seamless, interoperable information and decision support capability and one fused picture of the expanded logistics battlespace.
- *I.02, Joint Biological Remote Early Warning System ACTD,* will develop and demonstrate technologies providing remote early warning of biological warfare attacks.
- *I.03, Airbase/Port Biological Detection ACTD,* will demonstrate technologies providing local warning and response capability to counter biological warfare attacks.
- *I.05, Chemical Enhancement to Airbase/Port Biodetection ACTD,* enhances systems being developed in DTO I.02 to provide a capability for detection and warning against chemical as well as biological attacks.
- *J.03, Counterproliferation I ACTD,* will develop and demonstrate technologies to target and defeat hardened chemical and biological weapon storage and production facilities.
- *J.04, Counterproliferation II ACTD,* will develop and demonstrate technologies to target and defeat hardened chemical and biological weapon storage and production facilities.
- *CB.14.07, Prediction and Mitigation of Collateral Hazards,* will establish a capability to accurately predict WMD threats to military and civilian populations.
- *CB.17.01, Survivability Assessments Technology,* will develop and apply technologies to validate C^3I network survivability.
- *GV.01.06, Future Scout and Cavalry System,* will demonstrate the operational potential of a lightweight scout vehicle providing real-time target acquisition, identification, prioritization, and dissemination; enhanced mobility; ease of transportability and deployability; and enhanced survivability.

- *GV.02.06, Future Combat Vehicles*, will develop a leap-ahead replacement for the current-generation main battle tanks. Compared with the current tank, it will provide a system that has a reduced crew, is 50 percent lighter and 20 percent more fuel efficient, and has 100 percent greater cross country mobility. It will also have a significantly enhanced line-of-sight lethality and a significant non-line-of-sight lethality.
- *GV.14.00, Reconnaissance, Surveillance, and Targeting Vehicle*, will develop a vehicle that is V–22 transportable and incorporates advanced survivability, RSTA sensors, and C^2 links for enhanced sensor-to-shooter capability. It will provide a two- to threefold increase in strategic and tactical mobility over current mounted reconnaissance forces with a reduced logistics burden and increased target acquisition capability.
- *HS.10.05, Force XXI Land Warrior*, will improve individual and small-unit operational effectiveness by integrating advanced components—such as wireless weapon and sensor interfaces, enhanced navigation capabilities, embedded combat ID functions, helmet-mounted display upgrades, a head orientation sensor for more rapid target acquisition, a miniature chemical agent detector, and a personal status indicator—onto the Land Warrior platform. The availability of enhanced Land Warrior components and systems support the concept of Force Projection/Dominant Maneuver.
- *HS.18.02, Precision Offset, High-Glide Aerial Delivery of Munitions, Equipment, and Personnel*, will demonstrate revolutionary technologies for the reliable precision-guided delivery of combat-essential munitions/sensors, equipment, and personnel using high-glide wing and high-altitude life support.
- *IS.03.01, Integrated Force and Execution Management*, will provide warfighters with the ability to monitor, control, and coordinate real-time events inappropriate or impractical for traditional planning and forecasting activities. This capability includes in-stride retasking, retargeting, and weaponeering for multiple, dispersed units, thus providing fully coordinated operations across the force. This will result in faster adjustment of mission plans, a reduction in casualties and fratricide, and an improvement in force synchronization.
- *SE.37.01, High-Density, Radiation-Resistant Microelectronics*, will develop system-level technology to ensure that mission-critical systems (e.g., satellites) can withstand radiation hazards.
- *WE.50.02, Compact Kinetic Energy Missile Technology*, will develop and demonstrate kinetic energy missile technology necessary for the next-generation LOSAT missile.

2. Joint Countermine

Figure X–6 presents the technologies needed to breach the limitations to functional capabilities required to achieve the joint countermine objective. These technologies offer the potential for a significant increase in today's capability. Their need is underscored by experience in the Persian Gulf War, Somalia, and Bosnia.

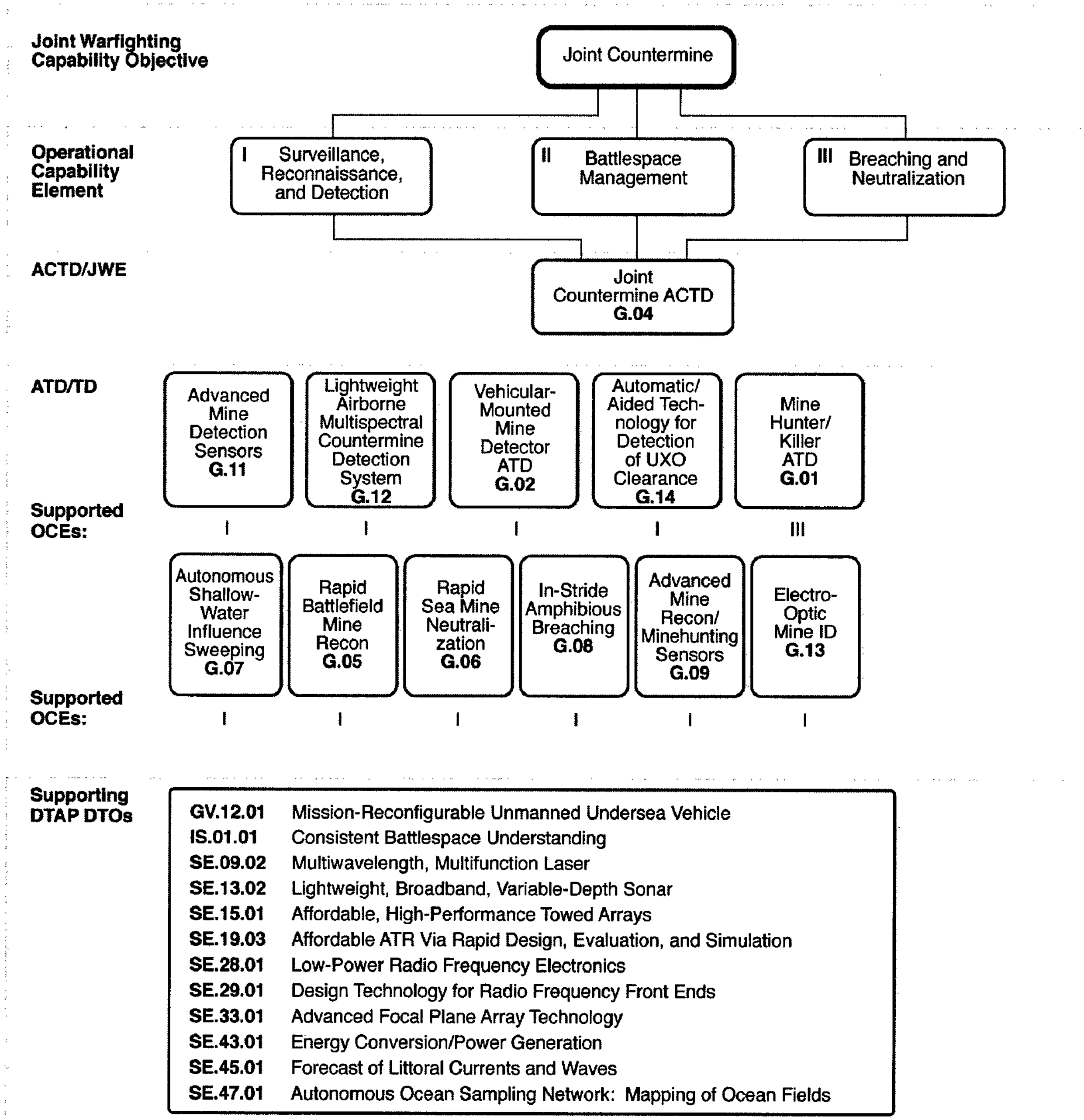


Figure X–6. Technology to Capability—Joint Countermine

Table X–7 identifies the Joint Countermine DTOs. Table X–8 presents the DTOs that, when attained, will enable the operational capability elements. Each DTO is plotted in Figure X–7, the roadmap for developing and demonstrating the technologies required to support Joint Countermine. This diagram shows the demonstrations that result from three serial processes: phenomenology, technology, and integration. Phenomenology addresses the understanding of the physical effects that influence mine detection, detonation, and negation. These effects include a better understanding of hydrographic phenomena in shallow and littoral waters and the surf zone, acoustic and electromagnetic mine and minefield signatures, and the reaction of explosives to chemical and energetic perturbation (pressure, directed energy, etc.). Technology enables the design of various sensor and neutralization systems, including algorithms for the detection and identification of minefields and for the exploitation of all available data (tactical sensors, intelligence sensors, and threat databases).

Table X–7. Defense Technology Objectives—Joint Countermine

DTO No.	Title
G.01	Mine Hunter/Killer ATD
G.02	Vehicular-Mounted Mine Detector ATD
G.04	Joint Countermine ACTD
G.05	Rapid Battlefield Mine Reconnaissance
G.06	Rapid Sea Mine Neutralization
G.07	Autonomous Shallow-Water Influence Sweeping
G.08	In-Stride Amphibious Breaching
G.09	Advanced Mine Reconnaissance/Minehunting Sensors
G.11	Advanced Mine Detection Sensors
G.12	Lightweight Airborne Multispectral Countermine Detection System
G.13	Electro-Optic Mine Identification
G.14	Automatic/Aided Technology for Detection of Unexploded Ordnance Clearance
GV.12.01	Mission-Reconfigurable Unmanned Undersea Vehicle
IS.01.01	Consistent Battlespace Understanding
SE.09.02	Multiwavelength, Multifunction Laser
SE.13.02	Lightweight, Broadband, Variable-Depth Sonar
SE.15.01	Affordable High-Performance Towed Arrays
SE.19.03	Affordable ATR via Rapid Design, Evaluation, and Simulation
SE.28.01	Low-Power Radio Frequency Electronics
SE.29.01	Design Technology for Radio Frequency Front Ends
SE.33.01	Advanced Focal Plane Array Technology
SE.43.01	Energy Conversion/Power Generation
SE.45.01	Forecast of Littoral Currents and Waves
SE.47.01	Autonomous Ocean Sampling Network: Mapping of Ocean Fields

Table X–8. Demonstration Support—Joint Countermine

Demonstration	Operational Capability Elements										Service/ Agency	Type of Demonstration		
	Surveillance, Reconnaissance, and Detection			Breaching and Neutralization		Battlespace Management								
	Continuous Surveillance	High Rate Area Reconnaissance/Detection	Precision Mine Location	Route Clearance, Sweeping, and Breaching	Area Clearance	Avoidance	Marking	Reporting	Recording	Dissemination		DTO	ACTD	ATD
Mine Hunter/Killer ATD				●		○					Army	G.01		X
Vehicular-Mounted Mine Detector ATD			●	●	○	●	○	○			Army	G.02		X
Joint Countermine ACTD	●	●	●	●	●	●	●	●	●	●	Army, Navy	G.04	X	
Rapid Battlefield Mine Reconnaissance		●		○	○	○	○	○			USMC	G.05		(C)
Rapid Sea Mine Neutralization			○	●	●						Navy	G.06		X
Autonomous Shallow-Water Influence Sweeping				●	●						Navy	G.07		(C)
In-Stride Amphibious Breaching				●							Navy	G.08		(C)
Advanced Mine Reconnaissance/Minehunting Sensors		○	●			●					Navy	G.09		(C)
Advanced Mine Detection Sensors			●								Army	G.11		
Lightweight Airborne Multispectral Countermine Detection System		●		○	○	○	○	○			Army, USMC	G.12		
Electro-Optic Mine Identification		●	●	○	○	○	○	○			Navy	G.13		(C)
Automatic/Aided Technology for Detection of Unexploded Ordnance Clearance	●	●	●	●	●	○	○	○			Army	G.14		
Mission-Reconfigurable Unmanned Undersea Vehicle	●	●	○	○							Navy	GV.12.01		
Consistent Battlespace Understanding								●	●	●	Air Force, Navy, DARPA	IS.01.01		
Multiwavelength, Multifunction Laser			●								Air Force	SE.09.02		
Lightweight, Broadband, Variable-Depth Sonar		○	●			●					Navy	SE.13.02		

● Strong Support ○ Moderate Support (C) 6.3 Core Demo

Table X–8. Demonstration Support—Joint Countermine (continued)

Demonstration	Operational Capability Elements: Surveillance, Reconnaissance, and Detection: Continuous Surveillance	High Rate Area Reconnaissance/Detection	Precision Mine Location	Breaching and Neutralization: Route Clearance, Sweeping, and Breaching	Area Clearance	Battlespace Management: Avoidance	Marking	Reporting	Recording	Dissemination	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Affordable High-Performance Towed Arrays		○	●			●					Navy	SE.15.02		
Affordable ATR via Rapid Design, Evaluation, and Simulation			●	○		○					Army, Air Force	SE.19.03		
Low-Power Radio Frequency Electronics	●	●	●			●	○	○	○		Air Force, DARPA	SE.28.01		
Design Technology for Radio Frequency Front Ends	●	●	●			●	○	○	○		Air Force, DARPA	SE.29.01		
Advanced Focal Plane Array Technology	●	●	●			●	●	○	○		Air Force, Navy, DARPA	SE.33.01		
Energy Conversion/Power Generation	○	○	○	○	○						Navy, Air Force, DARPA	SE.43.01		
Forecast of Littoral Currents and Waves						○	●	●	●	●	Navy, Army	SE.45.01		
Autonomous Ocean Sampling Network: Mapping of Ocean Fields	●	○	●			●	●	●	●		Navy, Army	SE.47.01		

● Strong Support ○ Moderate Support (C) 6.3 Core Demo

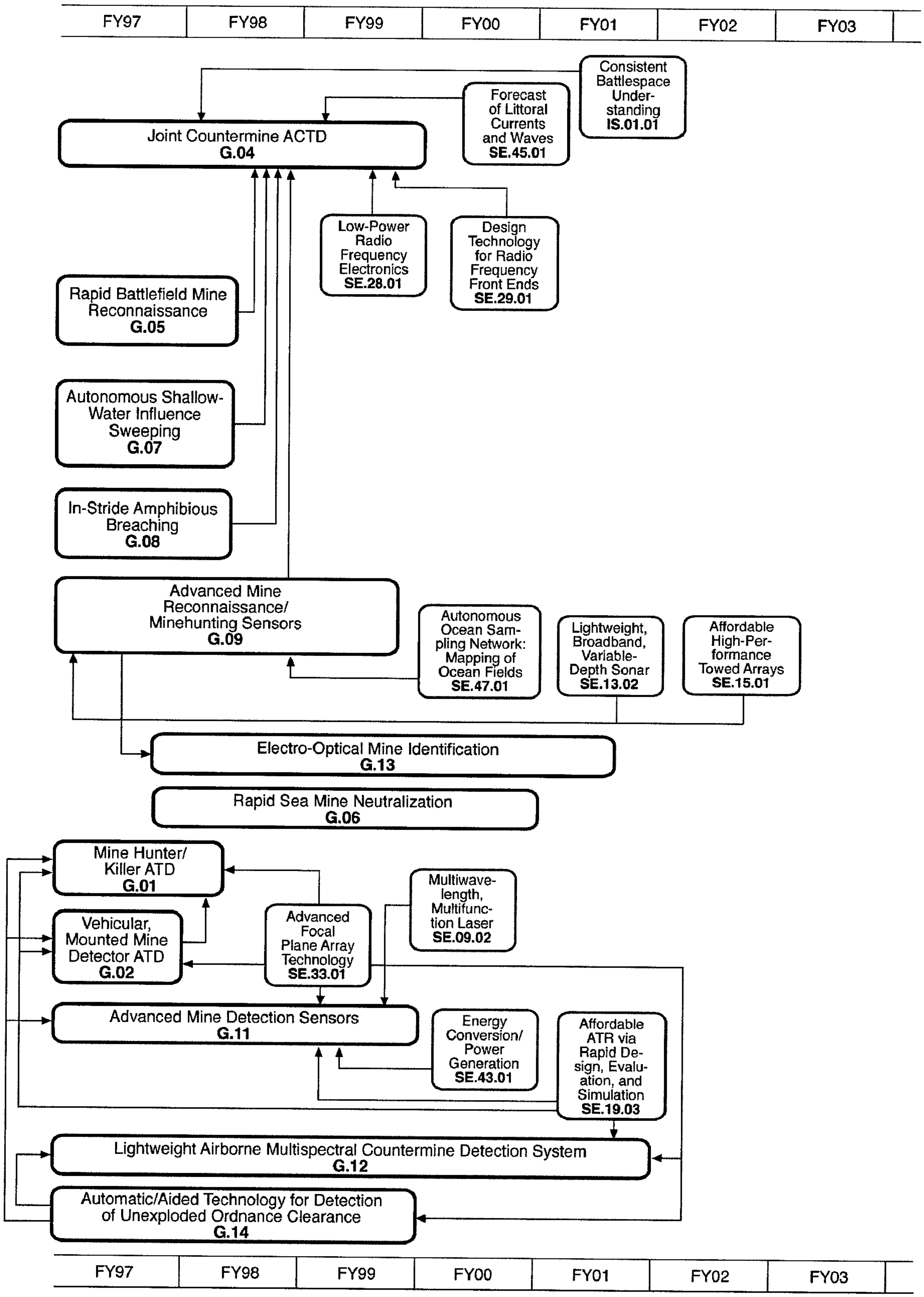


Figure X–7. Roadmap—Joint Countermine

A new DTO, G.14, Automatic/Aided Technology for Detection of Unexploded Ordnance Clearance, has been added as a result of recommendations from the Automatic Target Recognition (ATR) IPT. This DTO will focus technology on the difficult problem of UXO detection for mine clearing in tactical operations and humanitarian demining operations. This effort is supported by DTAP DTO SE.19.03, Affordable ATR via Rapid Design, Evaluation, and Simulation. Integration represents the effort required to put technologies on a militarily significant platform for demonstration. Integration also addresses the critical need to provide a comprehensive C^4I capability, which includes near-real-time, high-confidence situational awareness of the mine threat, the location and availability of friendly forces and their countermine capabilities, and coordination among service and coalition forces to optimize countermine effectiveness.

The technology efforts include several projects in the Army, Navy, and Marine Corps S&T programs. Following is a list by DTOs:

- *G.01, Mine Hunter/Killer ATD,* will provide a capability to neutralize individual mines and other UXOs from a mounted platform at maneuver speeds by integrating advanced mine detection and mine neutralization technologies with automated targeting and fire control mechanisms. This capability increases operational tempo by avoiding time delays due to mines and enhances force survivability by avoiding direct- and indirect-fire kills resulting from minefield delays. This DTO focuses on the neutralization component of the MH/K ATD.
- *G.02, Vehicular-Mounted Mine Detector (VMMD) ATD,* provides the capability to detect surface-laid and buried mines and other UXO from a vehicle-mounted system through development of new sensors and integration with sensor fusion and automatic mine recognition techniques (SE.19.03, Affordable ATR via Rapid Design, Evaluation, and Simulation). VMMD increases operational tempo and reduces losses caused by mine threats. This DTO includes the VMMD ATD and the detection component of the MH/K ATD (G.01).
- *G.04, Joint Countermine (JCM) ACTD,* will demonstrate selected clandestine reconnaissance and detection technologies and in-stride neutralization and clearance technologies, together with currently fielded capabilities, to improve the task force commander's ability to conduct seamless countermine operations. The goals of the JCM include demonstration of standoff reconnaissance and detection of mines and minefields in an amphibious operating area, in very shallow water, in the surf zone, on the beach, and on land; the in-stride movement through the surf zone, beach, and land using standoff neutralization; and countermine battlespace awareness through use of the Joint Countermine Operational Simulation (JCOS) and unique Countermine C^4I applications.
- *G.05, Rapid Battlefield Mine Reconnaissance,* includes the Coastal Battlefield Reconnaissance and Analysis (COBRA) ATD. COBRA incorporates advanced multispectral sensors into a UAV to provide daylight coastal reconnaissance of beach areas and craft landing zones. It addresses the limitation in high-search-rate reconnaissance capabilities of minefields and obstacles on the beach and improves the capabilities of forces to determine precise minefield boundaries.
- *G.06, Rapid Sea Mine Neutralization,* includes the Rapid Airborne Mine Clearance System (RAMICS) ATD. RAMICS employs a laser system to target super-cavitating

projectiles fired from a conventional 20-mm gatling gun mounted on a helicopter. The system will provide a capability to rapidly neutralize near-surface moored mines, addressing a shortfall in the ability of Airborne Mine Countermine (AMCM) forces to rapidly neutralize mines once they are identified.

- *G.07, Autonomous Shallow-Water Influence Sweeping,* includes the Advanced Lightweight Influence Sweep System (ALISS). ALISS will use superconducting magnet and plasma-discharge pulse power technology to provide lightweight acoustic and magnetic signature emulation sweeping. It can be deployed from a variety of platforms, including high-speed boats, Landing Craft Air Cushions (LCACs), or traditional MCM ships. ALISS fills a shortfall in the ability to rapidly sweep amphibious craft landing lanes in shallow water and provides a rapid-response capability for organic mine clearance.
- *G.08, In-Stride Amphibious Breaching,* includes the Explosive Neutralization Technology Demonstration (EN–Tech Demo). EN–Tech Demo will demonstrate in-stride mine and light obstacle breaching from the sea using improved explosive line charges and distributed explosive arrays deployed from an LCAC. An improved fire control system and longer range rocket motors will allow the LCAC to hover outside the surf zone in conditions up to sea state 3 while launching explosive charges. The Magic Carpet concept enables the deployment of explosive beach zone arrays by an unmanned glider launched by a cargo aircraft flying offshore, significantly reducing the shortfalls in the joint force's ability to conduct successful in-stride breaching in support of amphibious operations.
- *G.09, Advanced Mine Reconnaissance/Minehunting Sensors,* includes the Advanced Underwater Sensors Program. This effort is developing a family of acoustic and non-acoustic sensors for rapid, reliable underwater mine/minefield reconnaissance. The effort features computer-aided detection/classification, long-range sonar for the detection of mines in the water volume, high-resolution sonar for the reliable detection and classification of buried and partially buried mines, highly sensitive cryogenic magnetic gradiometers for mine classification and detection of buried mines, and electro-optic laser line scan sensors for mine identification. The sensors will be available for incorporation into a variety of UUVs, including autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs), and towed bodies.
- *G.11, Advanced Mine Detection Sensors,* provides enhanced mine detection capability through the fusion of outputs from multiple sensors—including advanced forward-looking IR, forward-looking radar, and side-looking radar—to overcome natural and man-made clutter. The goals are to provide a single ground-based detection system with a probability of detection (P_d) of 98 percent for antitank and antipersonnel mines, a false alarm rate of <0.2 per meter of forward progress, and an ability to operate in all weather. The mine detection contribution of seismic, acoustic, and bio-inspired sensors will be incorporated as these technologies mature.
- *G.12, Lightweight Airborne Multispectral Countermine Detection System,* provides innovative concepts and technologies to support a new, lightweight, airborne standoff mine detection sensor for integration into the tactical UAV. This DTO focuses on new IR focal plane array technologies, multi/hyperspectral imaging, passive polarization, active sources, and electronic stabilization. The goals of the DTO are to reduce the

weight and volume of the mine detection sensor package to allow direct interface with the tactical UAV, and enhance detection performance over the current Airborne Standoff Minefield Detection System (ASTAMIDS).

- *G.13, Electro-Optic Mine Identification,* provides technologies to rapidly identify volume, bottom, and partially buried sea mines at extended ranges in highly turbid environments. This DTO pursues a variety of laser-based imaging systems (Streak Tube Imaging LIDAR, Laser Line Scan) and associated image processing for use by either helicopter-towed or remote vehicles. Underwater mine identification eliminates operational delays associated with unnecessary asset allocations or diversions around objects that are subsequently proven to be something other than mines. This technology will enable quicker force projection and amphibious beach assaults.
- *G.14, Automatic/Aided Technology for Detection of Unexploded Ordnance Clearance,* provides technology to improve the ability of clearance personnel to detect, locate, access, identify, evaluate, neutralize, recover, and dispose of UXO. It emphasizes the automation technologies needed to support UXO clearance and will provide scientific understanding, analysis, methodology, and theory to aided "target detection" of UXO. This program will provide improved automatic/aided target detection and recognition algorithms to accomplish robust search, detection, and neutralization of UXO in support of countermine, humanitarian demining, EOD, and environmental remediation programs.

The primary mechanism for consolidating these projects into an integrated system-of-systems is the Joint Countermine ACTD (DTO G.04), sponsored and executed by USACOM and developed and managed by a Navy/Marine Corps/Army Joint Program Office. The two key integration activities in this ACTD are the C^4I effort and the Joint Countermine Operational Simulation (JCOS) project. Under the C^4I effort, the Joint Task Force Commander will be provided a complete, up-to-date situation awareness of the countermine intelligence and status along with direct connectivity to all maneuver units via existing or planned communications links. Global Command and Control System (GCCS)-compatible countermine warfighting evaluation tools and tactical decision aids (TDAs) will support all aspects of the littoral countermine effort, including minefield and obstacle surveillance and reconnaissance, mine and obstacle detection and avoidance, mine classification, and mine and obstacle clearance. The JCOS links existing modeling and simulation tools along with representatives of all countermine platforms and units in a distributed interactive simulation (DIS) framework consistent with the JCM/C^4I net to provide a comprehensive planning, training, rehearsal, and operational evaluation tool for joint countermine operations.

A critical area that has not previously been identified as a DoD mission is that of humanitarian demining. In June 1997, the Director (Acting) of Defense Research and Engineering briefed the White House Office of Science and Technology Policy (OSTP) on three new Multidisciplinary University Research Initiatives (MURIs) that address the technology required for humanitarian demining. Figures X–8 and X–9 summarize the problem and the current technology focus for these efforts. The humanitarian demining R&D program focuses on basic research demonstration, development, and evaluation of equipment to reduce the time and costs associated with demining while improving the operational safety of deminers. This program is not a basic research program; rather, it has integrated elements spanning basic research through technology demonstrations. The basic research program is accomplished through the MURI focused on humanitarian demining. The demonstration

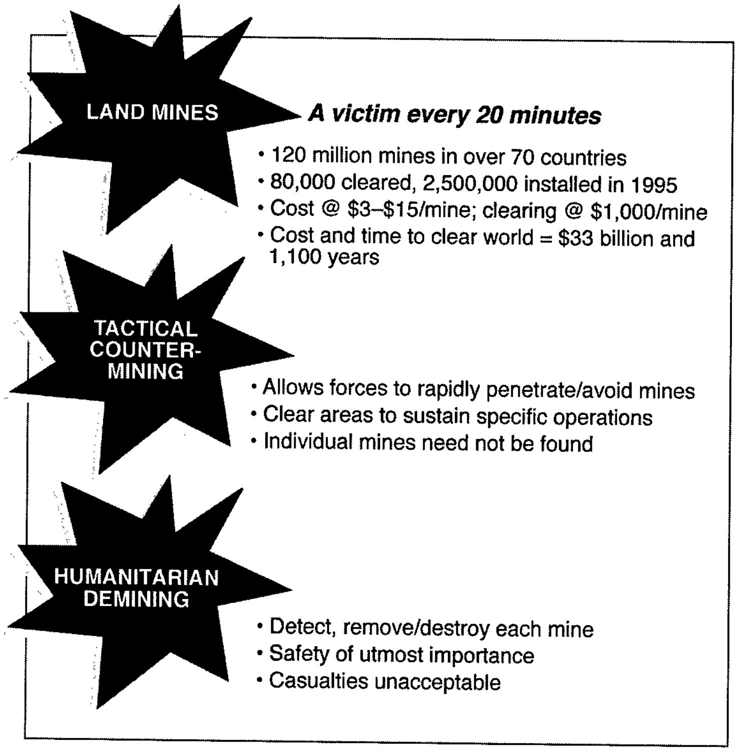


Figure X–8. The Problem

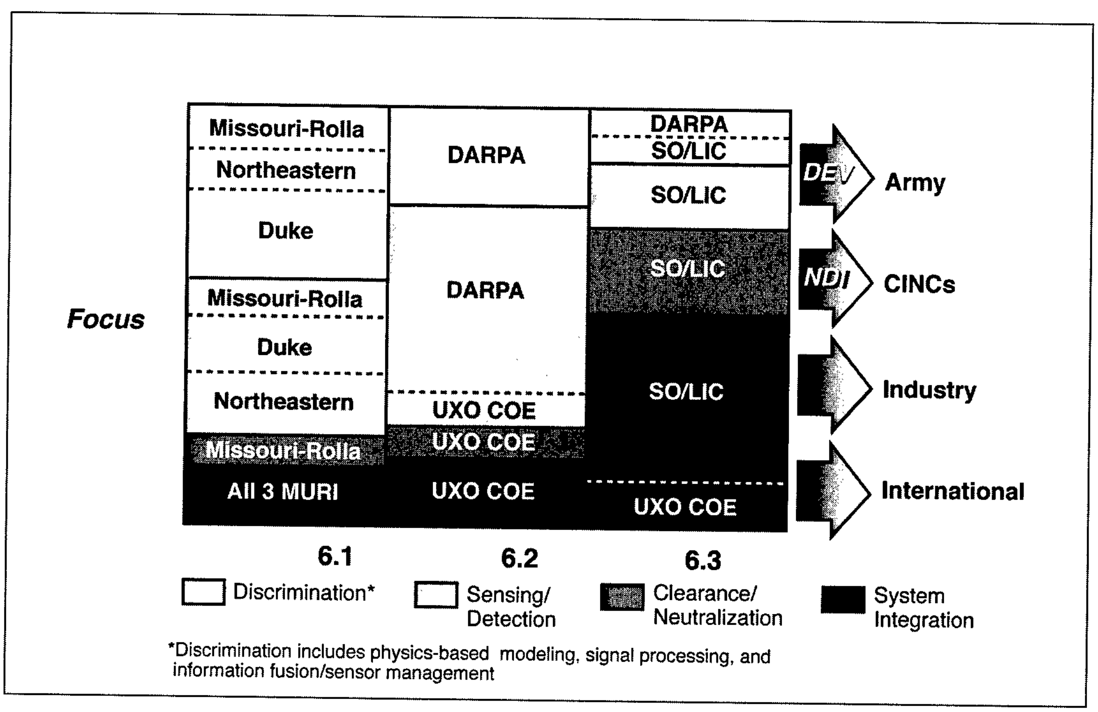


Figure X–9. Humanitarian Demining Focus

program includes adaptation of commercial off-the-shelf equipment and mature technologies to rapidly demonstrate and effect the transition of equipment for landmine detection, landmine clearance, protection of deminers, and mine awareness training to the international demining community.

The MURI program is accomplished through three consortia. Technologies being pursued include statistically based signal processing, laser stimulated acoustic detection, and adaptive sensor data fusion. The demonstration program seeks to leverage past and current R&D project activity in related areas, including tactical countermine, UXO clearance, and foreign development programs. Four areas of emphasis are currently being addressed by this development program: equipment to locate mined and mine-free terrain, clearers specialized for demining agricultural areas and neutralization devices to destroy individual mines without moving them, tools for the deminer to enhance their safety, and various media to facilitate mine awareness and deminer training. Figures X–8 and X–9 indicate the magnitude of the problem and the current focus.

Humanitarian demining needs and sustainment issues originate with the regional commanders in chief during the annual demining action officers' workshop. These needs and issues are refined with data from the United Nations, international groups, nongovernment organizations (NGOs), and contractors experienced in demining operations. The National Security Council's Interagency Working Group R&D Demining Subcommittee reviews and approves a prioritized needs/requirements list, and the program is subsequently authorized for execution by the Assistant Secretary of Defense for Special Operations and Low-Intensity Conflicts.

Additionally, individual service 6.2 and 6.3 core programs in various areas—including environment, sensors, explosives, and countermine—contribute significantly to the joint countermine effort. To eliminate duplication of efforts and provide focus for UXO detection and clearance technologies, DoD has established a Joint UXO Center of Excellence to serve as an integrating and coordinating agent for UXO technology development managers. Figure X–10 shows the conceptual layout for the UXO COE.

The UXO COE covers five mission areas within DoD: Countermine, Explosive Ordnance Disposal (EOD), Humanitarian Demining, Environmental Remediation, and Active Range Clearance. The mission of the UXO COE is to identify and eliminate duplication of effort, and promulgate a standard disciplined approach to testing and analysis. Several other related efforts also

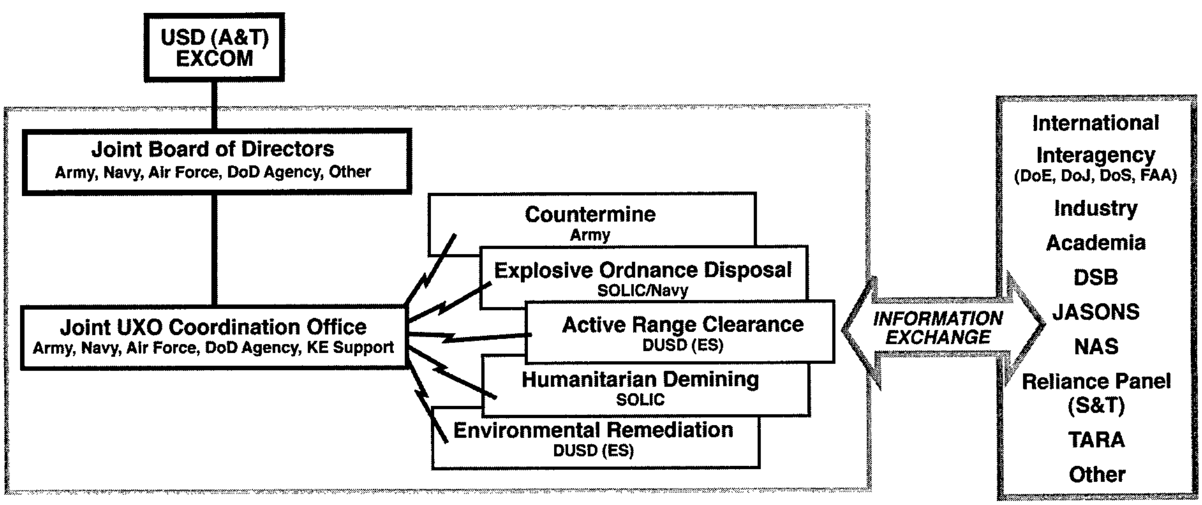


Figure X–10. Conceptual Layout for the UXO COE

have the potential to help countermine efforts. The Army Environmental Center recently completed a range cleanup technology program at the Jefferson Proving Ground. DOE and EPA requirements for test range and dump site redemption have led to the joint DoD/DOE Mobile Underwater Debris Survey System (MUDSS) project. Sandia National Laboratory is exploring foam bridges for minefield breaching and chemical sensing devices for mine reconnaissance. DARPA has an ongoing mine hunting UUV program and is developing a synthetic aperture sonar for underwater mine reconnaissance. DARPA is also investing in low-cost robotic technology for use in very shallow water, surf zone, and beach zone mine and obstacle clearance.

F. SUMMARY

1. Projection and Maneuver Dominance

The expected increase in our ability to execute Force Projection/Dominant Maneuver over time, as each of the supporting DTOs is met, is depicted in Figure X–11, which summarizes the capability provided by each DTO and the schedule for its demonstration. The sum of these capabilities will significantly enhance our ability to respond to time-urgent threats to national security by enabling rapidly deployable forces to swiftly achieve dominance at sea, in the air, and on the ground (for a limited period of time) against potential threats in most operational environments, including urban terrain, by providing them assured, theater-wide situation understanding and access to effective remote fires.

2. Joint Countermine

In FY1997 an additional thrust has been added to this year's submission of the Joint Warfighter's required capabilities: humanitarian demining (HD)—the detection and neutralization of landmines scattered indiscriminately by warring parties in many nations of the world. DoD recognizes the need to continue strong focus within the Defense Department to ensure oversight and coordination of technology developments supporting UXO clearance and to preclude duplication. As a result, DoD has set up a UXO Center of Excellence (COE) to establish standards for testing, modeling, and evaluation of UXO clearance technology. Details of the DoD initiatives are described in a USD(A&T) report to Congress on UXO clearance (Reference 19).

Another important area where significant progress has been made in FY1997 is that of the Joint Countermine ACTD. In this year's demonstration, a number of technologies from the Joint Countermine DTOs were employed in realistic environments during a major fleet/force exercise.

Joint Countermine activities, including humanitarian demining, are critical Joint Warfighter capabilities. These Joint Countermine efforts have resulted in a focused, coordinated technology plan involving the user communities from all the services.

From 1998, DoD will continue to enhance the warfighting capability of the services. The collective capabilities demonstrated for each DTO scheduled between 1997 and 2005 show a stepped improvement over the previous demonstration. The capabilities and their schedule of availability are depicted in Figure X–12. Through combined joint countermine capabilities and user awareness of the growing mine threat, the overall joint countermine objective of providing seamless mine and minefield detection and neutralization in a force projection from the sea to inland targets will be realized.

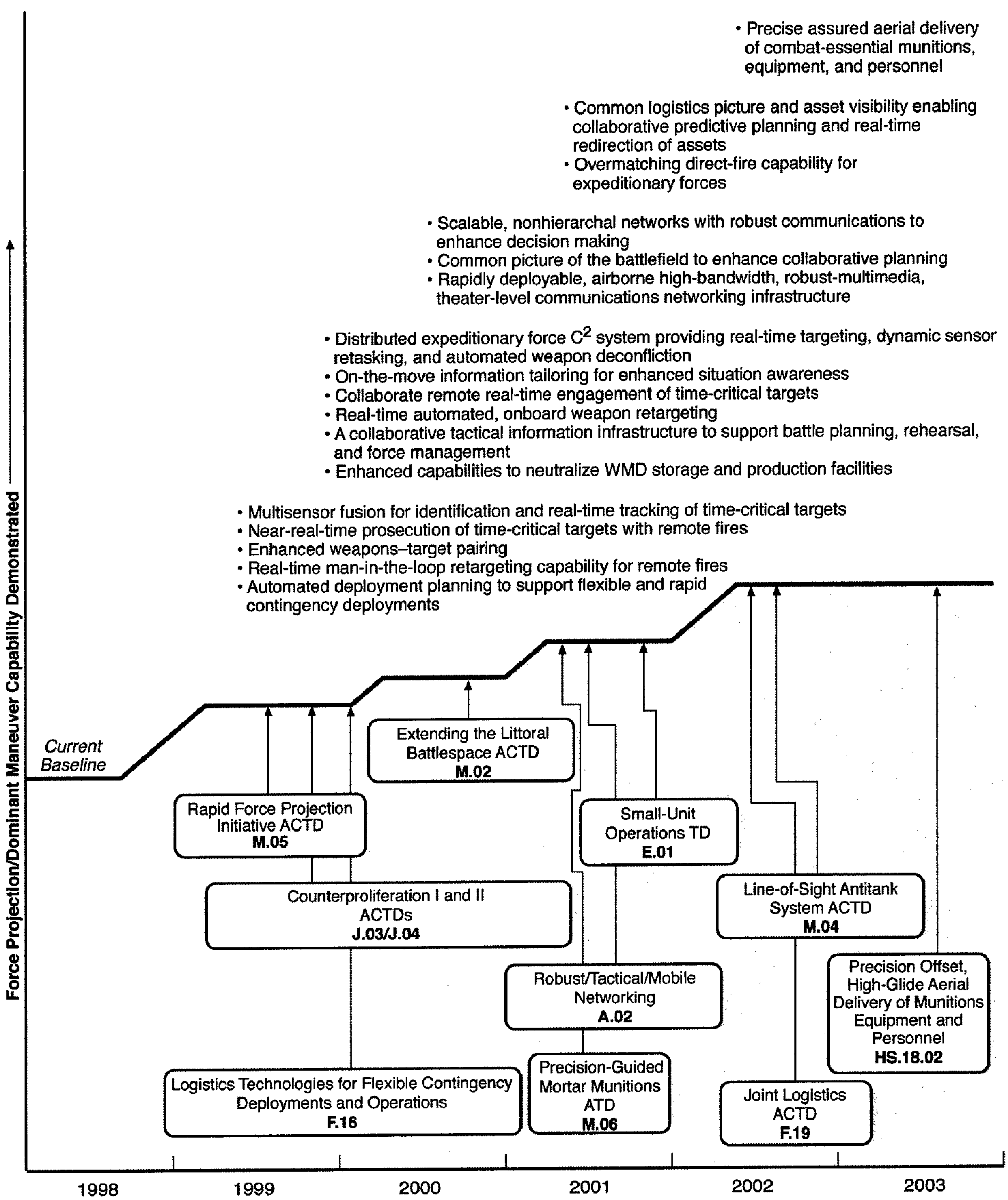


Figure X–11. Progress—Force Projection/Dominant Maneuver

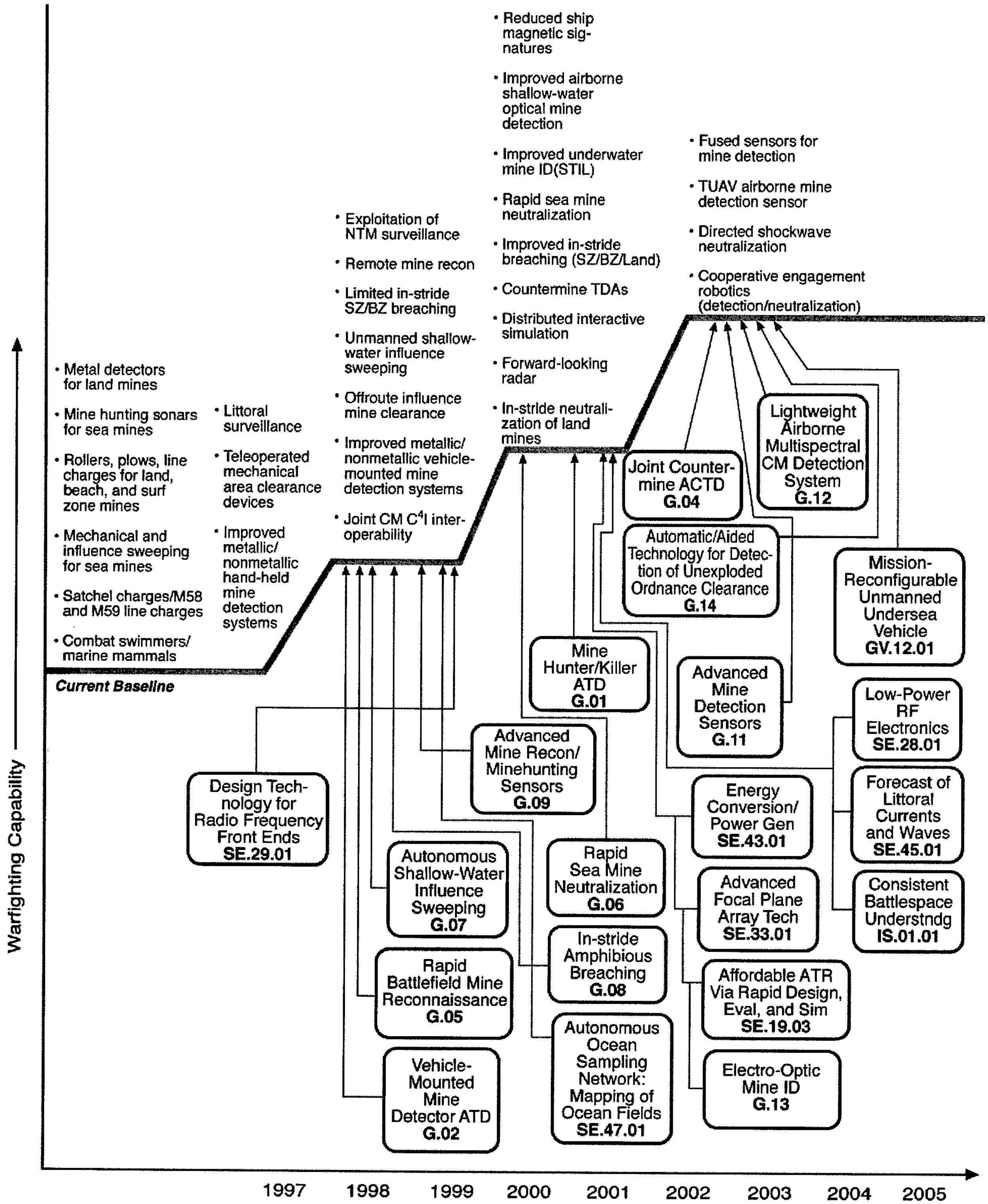


Figure X–12. Progress—Joint Countermine

CHAPTER XI

ELECTRONIC COMBAT

CHAPTER XI
ELECTRONIC COMBAT

A. DEFINITION

Electronic Combat (EC) encompasses the capability to disrupt or degrade an enemy's defenses throughout the areas and times—and across the entire electronic, infrared (IR), and visual spectrums—required to permit the deployment and employment of U.S. and allied combat systems. EC (also known as electronic warfare, or EW) includes capabilities for deceiving, disrupting, or destroying enemy surveillance, command and control (C^2), and weapon systems/sensors (e.g., early warning, acquisition, and targeting functions) associated with the enemy's integrated air/area defense network. EC also includes the critical capabilities of recognizing attempts by hostile systems to track or engage U.S. or friendly forces, automatically initiating the appropriate countermeasures or defensive response, and protecting friendly systems through redundancy and hardening.

B. OPERATIONAL CAPABILITY ELEMENTS

The strategic goal of EC is to control and exploit the electromagnetic spectrum for maximum effectiveness of U.S. military operations—that is, to deny, disrupt, degrade, deceive, or exploit enemy use of the full electromagnetic spectrum while ensuring its use by friendly or joint forces. Successful attainment of this goal necessarily confers a superior capability on U.S. military and friendly forces to survive in their execution of all required combat, conflict operations, and missions. EC has three principal and integral operational capability elements: electronic attack, electronic protection, and electronic support. Each element provides a range of benefits to participants in joint organizations and operations. Figure XI–1 depicts these principal elements as they contribute to joint operations.

Electronic attack (EA) involves the defensive or offensive protection of U.S. forces and platforms against hostile weapon, sensor, and C^3 systems. In its traditional form (*self-protection*), EA consists of a warning receiver to warn of impending weapon attack (*attack warning*), expendable countermeasures, and a jamming system working in concert to prevent sensor-guided weapons from hitting their target. More recent technology further expands the boundaries of electronic attack by engaging sophisticated, long-range target acquisition sensors—such as airborne and space-based surveillance/synthetic aperture radars, and the increasingly modern communications supporting all phases of the enemy attack or defense—thereby becoming a key, integral element of battlespace dominance. Therefore, EC/EW and its EA element play a prominent, vital role in the new, "leveraged" concept of Full Dimensional Protection, as described in the Chairman of the Joint Chiefs of Staff's *Joint Vision 2010*.

One critical aspect of electronic attack is the ability to deny an opponent the reliable use of his own command, control, communications, and computer/intelligence, surveillance, and reconnaissance (C^4ISR) systems—thereby permitting U.S. platforms and forces to operate freely throughout the battlespace with minimal loss to hostile weapons. Such freedom is gained due to confusion, analysis, and decision delays induced and propagated within the enemy's C^4ISR infrastructure regarding the location(s), structure, and intent of joint forces. This EA strategy is an enabling

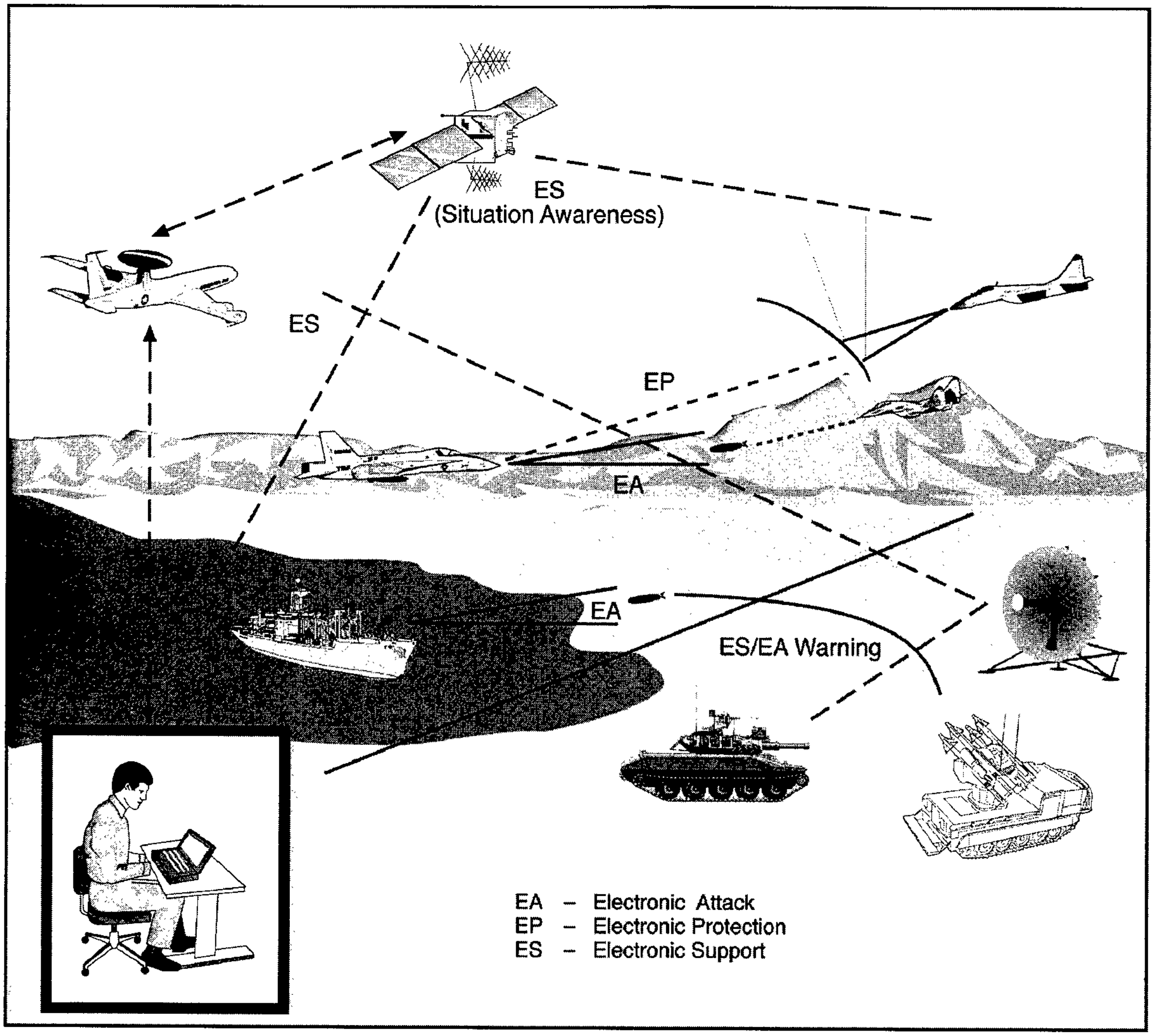


Figure XI–1. Concept—Electronic Combat

capability for operations requiring penetration of hostile territory (e.g., suppression of enemy air defenses (SEAD), close air support (CAS), counter-C^3, and precision attack on any fixed or mobile target). Thus, again, electronic attack plays a prominent role in the *Joint Vision 2010* concept of Dominant Maneuver by virtue of aiding the control of operational tempo, and EA is synergistic with the Joint Warfighting Capability Objective (JWCO) of Information Superiority.

Electronic protection (EP) supports the development of design features and employment techniques that allow U.S. forces to enjoy the benefits of accurate electronic sensors and systems, both offense and defensive—despite an environment that includes hostile jamming, deception activity, and enemy weapon targeting that, itself, depends on detecting, recognizing, and determining the location of U.S. emitters. EP allows operational users to initiate and prosecute a mission without degradation from opposing EW or from conventional or directed-energy weapons cued or targeted by hostile sensors. Successes in EP techniques translate into effective targeting by joint combatants and reliable communications, surveillance, and electronic support sensors—corresponding to the JWCOs of Precision Force and Information Superiority.

Electronic support (ES) is the EC element that gathers, consolidates, and employs information from hostile or potentially hostile electronic sensors and C^3 systems. ES is critical to developing a comprehensive picture of the battlespace and a reliable indication of hostile force movement and intentions. ES allows force avoidance, efficient engagement, and electronic deception—EA—of enemy sensors, weapons, and communications systems. The classic definition of electronic support recognizes its functionality from the joint operational commander level down to the "single-seat" cockpit combatant. With increasingly sophisticated, worldwide, modern weapon systems, the pressures for ever-increasing ES fidelity are blurring the older distinctions between the classic radar warning receiver (attack warning) and the longer range electronic support measures (ESM) systems. Therefore, in the future, all joint combatants/platforms can be integrated into the battlespace picture via the contributions of their ES systems. ES enables a wide range of operational options that contribute to virtually every combat and peacekeeping mission. Hence, ES is strongly synergistic with the JWCOs of Precision Force, Combat Identification, and Information Superiority and the associated *Joint Vision 2010* concept of Precision Engagement.

C. FUNCTIONAL CAPABILITIES

Table XI–1 depicts the relationships between operational capability elements and functional capabilities for the EA and ES components of EC. Because electronic protection capabilities are generally specific to a sensor or C^3 system, the EP component is not addressed further in this section.[1] From a basic technology perspective, refer to the *Defense Technology Area Plan* (DTAP), Chapter VII, Sensors, Electronics, and Battlespace Environment; and Chapter X, Weapons (EW Mission Support).

Table XI–1. Functional Capabilities Needed—Electronic Combat

	Operational Capability Elements									
	Electronic Attack							Electronic Support		
Functional Capabilities	Attack Warning	A/C Protection	Ship Protection	Land Combat Vehicle Protection	C^2 Attack	Lethal SEAD	Electronic Protection	Signal Collection	Emitter ID/ Location	Battlespace Awareness
1. Real-Time Threat Detection, ID, and Geolocation	●	●	●	●	●	●	Not addressed in this Joint Warfighting S&T Plan	●	●	●
2. Missile Approach Warning	●	●	●	●						●
3. Modular, Programmable EW Receiver/Processor	●	○	○	○	●	●		●	●	●
4. Sensor/Data Fusion, Electronic Intelligence	●	●	●	●	●	○		●	●	●
5. Decoy Terminal Threat Weapons		●	●	●		●				
6. UAV EW Employment	○	●	●	●	●	●		●	●	●
7. Robust, Multispectral EA of Simultaneous Threats		●	●	●		●				
8. Broadband, Coherent, Surgical RF Countermeasures		●	●	●	●	○				
9. Second-Generation Directed IRCM		●	●	●						
10. Laser-Based IRCM		●	●	●						
11. Counter IADS Surveillance, Acquisition, and C^2		●	●	●	●	○		○	○	○

● Strong Support ○ Moderate Support

[1] For example, protecting operational usage of GPS is dealt with, in part, by the Navigation Warfare ACTD.

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

Current EC/EW capabilities are generally the result of extensive, detailed concentration on the capabilities of the former Soviet Union; a coherent "successor" threat has not yet been established. However, it is clear that generic trends exist in global military technology that allow identification of the most prominent deficiencies and barriers to joint EW operations. Table XI–2 provides a top-level summary of capabilities, limitations, and key technologies to overcome current limitations and to provide those capabilities.

Table XI–2. Goals, Limitations, and Technologies—Electronic Combat

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Attack—Platform Protection			
>99% combined probability of no hostile weapon launches or misses	*Attack Warning* 1. Real-time RF threat detection, ID, and geolocation 2. Missile approach warning 3. Modular, programmable EW receiver/processor 4. Sensor/data fusion, electronic intelligence	1. Slow, inaccurate, and ambiguous threat ID, and bearing resolution 2. Limited probability of intercept in dense, high-signal, high-clutter environment 3. Simultaneous, overlapping signals 4. Incomplete/uncorrelated a priori database information 5. Unpredictable emitter mode changes, and tracking thereof	1. Advanced signal ID and detection algorithms 2. Distributed/parallel COTS multiprocessors 3. High-sensitivity, multiband detectors 4. Directional apertures 5. Digital and channelized receivers 6. Low-false-alarm, high-sensitivity missile warning, with accurate "time-to-go" 7. Real-time techniques for correlation/fusion of all-source information/data
	Expendable/Decoy Countermeasures 5. Decoy terminal threat weapons 6. UAV employment 7. Robust, multispectral EA of simultaneous threats	Item 1 above, plus: 6. Unmatched/incoherent spectral content and output profile/signatures 7. Tight packaging constraints 8. High cost of integrating multispectral capability(s) 9. Inaccurate ejection timing, leading to rapid stores depletion	Items 1, 3, 5, & 6 above, plus: 8. Enhanced IR flare materials 9. Kinematic/aerodynamic techniques 10. Digital RF memories (DRFMs) 11. VHSIC/application-specific ICs (ASICs) 12. MMIC/microwave power module (MPM) amplifier technologies 13. Cooperative DIRCM/ laser-based IRCM EA techniques (item15 below) 14. Signature modification/ control & location masking techniques (e.g. chaff, smoke, aerosols)
	Coherent Jamming Item 7 above, plus: 8. Broadband, coherent, surgical RFCM 9. Second-generation directed IRCM (DIRCM) 10. Laser-based IRCM 11. Counter IADS surveillance, acquisition, and C^2	Items 1, 2, 3, 5, 6, 7, & 8 above, plus: 10. High retrofit costs 11. Nonintegrated approach to EA of multispectral/multimode threats	Items 1, 3, 4, 5, 10, 11, 12, 13, & 14 above, plus: 15. Affordable, compact laser (min. 2 W/20 kHz, mid IR) 16. Coherent, doppler, monopulse, and false target CM techniques

Table XI–2. Goals, Limitations, and Technologies—Electronic Combat (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Electronic Attack—C^2W and SEAD			
Exploit, disrupt, deceive modern integrated defense system/network	*Complex C^2 Signal Identification* Items 1, 3, 4, & 6 above	Items 1, 2, 3, 5, 7, & 10 above, plus: 12. Insufficient low-noise signal intercept and decoding techniques 13. Inability to track/jam in real time	Items 1, 2, 4, 5, 7, & 11 above, plus: 17. Negative signal-to-noise signal and code ID/tracking algorithms 18. Parallel signal channel tracking and algorithm techniques 19. Near-real-time code-breaking techniques
Exploit, disrupt, deceive modern integrated defense system/network	*Nonfratricidal C^2 Jamming* Items 6, 8, & 11 above	Items 1, 2, 3, 5, 7, 10, & 13 above, plus: 14. Nonlinear power amplification 15. Imprecise coding/ signal demodulation 16. Poor beam/radiation control	Items 2, 5, 10, 11, 17, & 19 above, plus: 20. High-efficiency, linear, solid-state amplifiers (HF, VHF, UHF) 21. C^2-frequency MPMs 22. Efficient HF, VHF, UHF antenna designs (e.g., high-temperature superconductivity, arrays)
	Lethal SEAD Items 1, 3, 4, 5, 6, 7, 8, & 11 above	Items 1, 3, 4, 5, 6, 7, & 8 above, plus: 17. Affordability of UAV decoys 18. Affordable, compact RF support jamming (stand-off/ stand-in) techniques	Items 1, 2, 4, 5, 10, 11, & 12 above, plus: 23. Frequency/bandwidth aperture function control techniques (EA vs. ES) 24. Large-extent phased arrays
Operational Capability Element: Electronic Protection (Not considered in this document)			
Operational Capability Element: Electronic Support			
> 99% probability of signal intercept, detection, ID, and location across EM spectrum, mission, and battlespace	*High-Fidelity Signal Recognition and Tracking* Items 1, 2, & 3 above (item 2 in mission/platform context of MWS contributions to battlespace awareness/situation assessment)	Items 1, 2, 3, 4, 5, 10, & 12 above, plus: 19. Insufficient processing time and "power" 20. Little interoperability between operational/service systems	Items 1, 2, 3, 4, 5, 6, 7, 11, 17, 18, & 19 above, plus: 25. Sub-1-degree aperture/beamforming systems 26. Rapid (e.g., GHz), high-fidelity (e.g., 10–14 bit) analog-to-digital conversion hardware/processing 27. Software-reconfigurable/"open" architectures
> 99% probability of signal intercept, detection, ID, and location across EM spectrum, mission, and battlespace	*All-Source Data Integration/Fusion* Item 4 above	Items 1, 2, 3, 4, 5, 15, & 19 above, plus: 21. Inability to deal with missing, incomplete, and corrupted data	Items 1, 2, 4, 5, 7, & 27 above, plus: 28. Expert systems and algorithms (knowledge-based information representation and computer "reasoning" techniques that allow manipulation of sensor, text, and archival/library data in one process)
	Hostile Battlespace Signal Intercept/ Collection Items 6 & 11 above	22. Vulnerability of conventional manned platforms	Items 1, 2, 5, 7, 11, 19, 26, & 27 above, plus: 29. UAV payloads 30. Wideband data linking

The threat of passively guided weapons has increased dramatically over the past decade. Today, infrared-guided weapons pose a serious and growing threat to U.S. forces and platforms in the air, on land, and at sea. Inexpensive, portable missiles can be launched with ease and effectiveness against all airborne combatants. The threat of longer range infrared guided antiship missiles is equally great, and formidable in both at-sea and littoral scenarios. Land combat vehicles are similarly threatened by frontal and top-attack munitions guided by infrared and multispectral seekers. *Protection against infrared guided weapons is the highest priority need in electronic attack* and is an important deficiency that constrains the efficient execution of joint operations.

The technology barriers to resolutions of these EA deficiencies include inadequate detection range and angular resolution on attack warning systems to eject decoys or initiate jamming; insufficient power, low efficiency, and unacceptable size, weight, and cost of laser devices that could be used in countermeasure systems; and insufficient output power and excessive size, weight, and cost of high-power microwave systems for self-protection of platforms. Of particular concern in the high-power microwave arena is the integration of this weapons-level EC effect into operational concepts of Joint Forces—so as to avoid/mitigate the possible, self-inflicted, mission-degrading effects of electronics fratricide and platform "suicide." Each of these barriers is being addressed with ongoing technology demonstration programs.

As a second area of high EA priority, the rapid development and adoption of new communications technology has created deficiencies in the ability of U.S. forces to exploit and selectively disrupt modern signals. Cellular and personal communications systems used by civilians and hostile forces, and high-capacity digital, multichannel networks associated with distributed information systems, pose particularly difficult technical challenges. The ability to detect, analyze, exploit, and disrupt these signals is fundamental to the conduct of joint operations against an opponent with modern communications equipment and sensors. In the context of EA, jamming transmitters and antennas used against C^3 signals require improvements in precise modulation selection and modulator control, linearity, efficiency, output power, and directivity.

Electronic protection measures are generally specific to a sensor or C^3 system. EP measures entail the tailoring of generic protection technology and techniques (again, as treated in the respective DTAP sections) to satisfy the electronic protection requirements of a specific system in order to ameliorate the effects of hostile jamming, deception, targeting, or directed-energy attack. Although included as an element of EC, these efforts are an integral part of the sensor or C^3 development program (e.g., GPS). As stated previously and noted at the end of Table XI–2, further EP details are omitted from this section.

Electronic support is the activity that gathers timely information on hostile force composition, status, and intentions by intercepting and analyzing the signals from hostile electronic systems and integrating this information with that from our own forces and electronic systems—whether at the joint command, at-sea battlegroup, or single-seat cockpit/battlefield soldier level. The composition and characteristics of C^3 systems are changing rapidly as low-cost, high-performance digital technology becomes universally available. The proliferation of this technology has also encouraged the widespread availability of cellular and personal communications devices that are highly mobile and resistant to conventional electronic attacks. Optical fiber networks, coupled with increasingly more powerful computers, constitute the basis for powerful information systems that support sophisticated military C^3 functions as easily as civilian applications. These advances in processing and communications technology facilitate and encourage the acquisition of customized, unique C^3

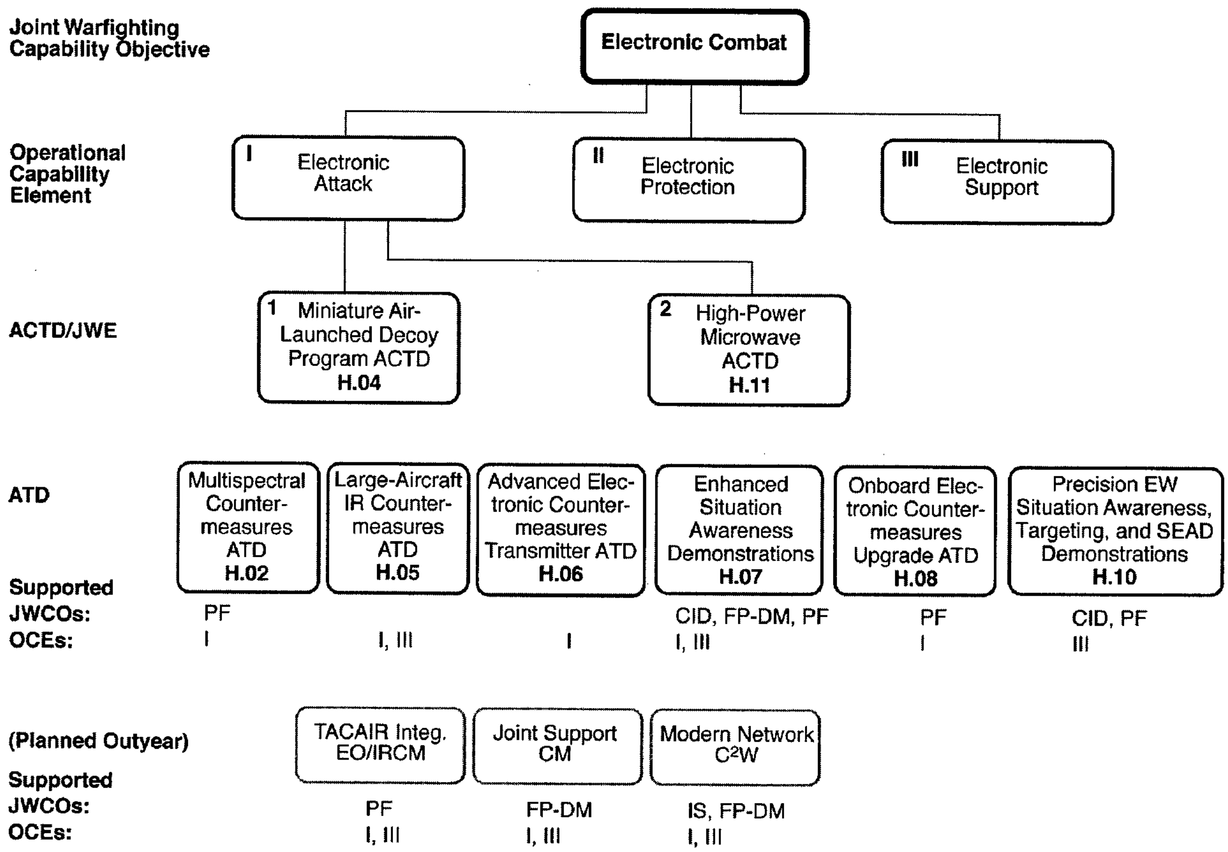
systems in the military forces of many small countries. This diversity and unpredictability constitutes a formidable challenge to ES organizations that must support operational users with services and products in any conceivable location and situation.

As advanced knowledge of threat system parameters—necessary for attack warning and countermeasure waveform development—becomes more difficult to obtain, EW receivers on tactical aircraft, ships, and land combatants will have to assume some of the burden formerly assigned to dedicated special signal collection receivers (i.e., the "blurring" regarding ES as discussed in Subsection B, above). This will be necessary to accumulate detailed information on classes of emitters, as well as individual emitters, and to support the development of generic system recognition algorithms.

The ability to fuse different forms of information from multiple sources is an important capability in an environment of mixed-media signals. Algorithms that can analyze and consolidate information from different sensors and databases can produce a product that is more complete and informative than the sequential examination of the individual contributions. Algorithms using expert system techniques and artificial intelligence principles can represent and manipulate knowledge faster and more exhaustively than is possible with human analysts in time-critical situations.

The technology deficiencies in electronic combat include incomplete development of technologies suitable for unmanned aerial vehicles (UAVs) for signal collection/ES missions (and linkages/extrapolations of this technology to broadband RF support EA countermeasures from UAV platforms); inadequate processing subsystems and algorithms for detection, identification, and analysis of new communications waveforms; unacceptable performance in signal collection against mixed-media networks containing fiber optic and other transmission media; and inadequate performance and excessive cost to acquire and maintain warning and signal collection capabilities in tactical EW receivers. Finally, current capabilities in the representation of data, automated sensor product analyses, and machine reasoning capabilities are insufficient to perform timely and complete sensor product and data fusion.

Figure XI–2 illustrates how technology developments support technical demonstrations that contribute to operational capability elements in Electronic Combat. Table XI–3 lists planned DTOs for EC, the details of which can be found in *Defense Technology Objectives of the Joint Warfighting Science and Technology Plan and the Defense Technology Area Plan* (Reference 6). Table XI–4 correlates the technical demonstrations with the operational capability elements that they support.



Supporting DTAP DTOs

WE.22.09	High-Power Microwave C^{2}W/IW Technology
WE.23.08	Modern Network Command and Control Warfare Technology
WE.40.08	Infrared Decoy Technology
WE.42.08	Laser Aircraft Self-Protect Missile Countermeasures
WE.43.08	Advanced Multiband Infrared Countermeasures Laser Source Solution Technology
WE.46.08	Coherent RF Countermeasures Technology
WE.47.08	Imaging Infrared Seeker Countermeasures Technology
WE.48.08	Missile Warning Sensor Technology
WE.60.09	High-Power Microwaves for Suppression of Enemy Air Defense

PF—Precision Force; CID—Combat ID; FP-DM—Force Projection/Dominant Maneuver; IS—Information Superiority

Figure XI–2. Technology to Capability—Electronic Combat

Table XI–3. Defense Technology Objectives—Electronic Combat

DTO No.	Title
H.02	Multispectral Countermeasures ATD
H.04	Miniature Air-Launched Decoy Program ACTD
H.05	Large-Aircraft Infrared Countermeasures ATD
H.06	Advanced Electronic Countermeasures Transmitter ATD
H.07	Enhanced Situation Awareness Demonstrations
H.08	Onboard Electronic Countermeasures Upgrade ATD
H.10	Precision EW Situation Awareness, Targeting, and SEAD Demonstrations
H.11	High-Power Microwave ACTD
WE.22.09	High-Power Microwave C^2W/IW Technology
WE.23.08	Modern Network Command and Control Warfare Technology
WE.40.08	Infrared Decoy Technology
WE.42.08	Laser Aircraft Self-Protect Missile Countermeasures
WE.43.08	Advanced Multiband Infrared Countermeasures Laser Source Solution Technology
WE.46.08	Coherent RF Countermeasures Technology
WE.47.08	Imaging Infrared Seeker Countermeasures Technology
WE.48.08	Missile Warning Sensor Technology
WE.60.09	High-Power Microwaves for Suppression of Enemy Air Defense

Table XI–4. Demonstration Support—Electronic Combat

<table>
<tr><th rowspan="2">Demonstration</th><th colspan="3">Operational Capability Elements</th><th rowspan="2">Service/ Agency</th><th colspan="3">Type of Demonstration</th></tr>
<tr><th>Electronic Attack</th><th>Electronic Protection</th><th>Electronic Support</th><th>DTO</th><th>ACTD</th><th>ATD</th></tr>
<tr><td>Multispectral Countermeasures ATD</td><td>●</td><td rowspan="11">Not addressed in this Joint Warfighting S&T Plan</td><td>○</td><td>Army</td><td>H.02</td><td></td><td>X</td></tr>
<tr><td>Miniature Air-Launched Decoy Program ACTD</td><td>●</td><td>○</td><td>DARPA, Air Force</td><td>H.04</td><td>X</td><td></td></tr>
<tr><td>Large-Aircraft Infrared Countermeasures ATD</td><td>●</td><td>●</td><td>Air Force</td><td>H.05</td><td></td><td>X</td></tr>
<tr><td>Advanced Electronic Countermeasures Transmitter ATD</td><td>●</td><td></td><td>Navy</td><td>H.06</td><td></td><td>X</td></tr>
<tr><td>Enhanced Situation Awareness Demonstrations</td><td>○</td><td>●</td><td>Air Force</td><td>H.07</td><td></td><td>X</td></tr>
<tr><td>Onboard Electronic Countermeasures Upgrade ATD</td><td>●</td><td>○</td><td>Air Force</td><td>H.08</td><td></td><td>X</td></tr>
<tr><td>Precision EW Situation Awareness, Targeting, and SEAD Demonstrations</td><td>○</td><td>●</td><td>Army, Air Force</td><td>H.10</td><td></td><td></td></tr>
<tr><td>High-Power Microwave ACTD</td><td>●</td><td></td><td>Air Force</td><td>H.11</td><td>X</td><td></td></tr>
<tr><td>Joint Service Support Countermeasures Demonstration</td><td>●</td><td>●</td><td>Air Force, Navy</td><td>(Planned)</td><td></td><td>X</td></tr>
<tr><td>Tactical Aircraft EO/IRCM</td><td>●</td><td>●</td><td>Air Force, Navy</td><td>(Planned)</td><td></td><td>X</td></tr>
<tr><td>Modern Network C^2W</td><td>●</td><td>●</td><td>Air Force, Army</td><td>(Planned)</td><td></td><td>X</td></tr>
</table>

● Strong Support ○ Moderate Support

E. TECHNOLOGY PLAN

The technology plan incorporates cooperative and synergistic DTO projects being conducted by the Army, Air Force, Navy, and DARPA. Below is a list of the efforts by DTO:

- *H.02, Multispectral Countermeasures ATD*, will develop and test an all-laser, open-loop infrared countermeasures (IRCM) capability for planned product improvement and upgrades for the ATIRCM hardware.
- *H.04, Miniature Air-Launched Decoy Program ACTD*, pursues the development of an affordable, air-launched decoy "stimulant" for application in the lethal suppression of enemy air defense (SEAD) mission.
- *H.05, Large Aircraft Infrared Countermeasures ATD*, is an effort to develop and demonstrate the necessary technologies to achieve the advanced, closed-loop IRCM capability for the self-protection of large aircraft.
- *H.06, Advanced Electronic Countermeasures Transmitter ATD*, will demonstrate a broadband radio frequency (RF)/microwave electronic countermeasure (ECM) jammer/transmitter technology, capable of defending surface ships against modern antiship missile and associated targeting/surveillance threat systems.
- *H.07, Enhanced Situation Awareness Demonstrations*, is an ATD-class program that will develop and demonstrate hardware and software approaches and techniques that provide aircrews timely threat warning/alert and enhanced situation awareness (SA).
- *H.08, Onboard Electronic Countermeasures Upgrade ATD*, will pursue advanced, integrated monopulse countermeasure techniques as an affordable, robust RFCM capability for use against the difficult coherent, monopulse class of threat radars.
- *H.10, Precision EW Situation Awareness, Targeting, and SEAD Demonstrations*, is a synergistic set of ATD-class efforts that will provide ground, rotary-wing, and tactical aircraft with the capability to precisely locate threat emitters via EW sensors, for SA and SEAD targeting.
- *H.11, High-Power Microwave ACTD*, will develop and demonstrate an HPM technology intended for the disruption, degradation, or destruction of electronics in a specified information operation threat scenario.

As emphasized in Section D above, a critical, coordinated tri-service plan to address vulnerability to IR missiles and weapons has been developed under Defense Reliance and is being executed. The program includes near- to mid-term measures to reduce vulnerabilities by using improved missile warning capabilities and advanced flares (DTAP DTOs WE.48.08, and WE.40.08, respectively). Coupled with laser source work under the DTAP (DARPA and WE.43.08), conventional laser-based infrared countermeasures (IRCM) solutions are in progress—notably the current work under DTOs H.02 (for rotary-wing aircraft) and H.05 (for large aircraft). H.02, scheduled for completion next fiscal year, attacks the problems of integrating advanced multiband laser, fiber optic, and *open-loop* jamming algorithm technologies in order to lay the foundation for planned improvements to the Army's Advanced Threat IRCM (ATIRCM) system (ALQ–211). H.05 will advance the IRCM state of the art via emphasis on the tough EW issues associated with end-to-end,

closed-loop technique implementations. This Large Aircraft IRCM ATD will proceed through live-fire cable car tests in FY1999/2000 and is pursuing funding options to implement a flight test phase (a 1997 TARA recommendation). Completed this past year was the TACAIR DIRCM ATD (part of old WE.03), which established additional baseline data on future open-loop, laser-based IRCM architectures for planned Reliance collaboration in the tactical aircraft arena. This DTO also pushes the state of the art in miniature pointer/tracker technology (ATIRCM engineering development subsystem).

Capabilities to attack hostile command and control (C^2) networks will vastly improve with the development of transmitters with more efficient power amplification; modern, digital, EA modulation formats; and greater angular precision. These enhancements will effectively increase jamming power on victim systems and reduce interference with U.S. and allied systems in the vicinity. A coordinated tri-service effort is developing signal separation, recognition, analysis, and countermeasure techniques against specific waveforms used in C^2 applications. These ES capabilities will be consolidated with the EA jamming improvements to produce an enhanced ability to selectively disrupt hostile communications and weapon control networks.

Similarly, a coordinated development is underway to design and integrate critical digital receiver/processor technologies to yield next-generation EW receivers and receiver upgrades. These receivers will be capable of performing warning, signal parameter collection, and situation assessment (SA); and assisting the functions of threat geolocation and combat identification (Combat ID). Associated architectures will integrate the advantages of broadband, channelized monolithic receivers "on a chip" with commercial, real-time, parallel digital signal processors to yield an affordable, adaptable, software-reconfigurable capability. In conjunction with past DARPA-sponsored work on advanced digital receiver components/interconnects, these capabilities will serve to fill a number of future operational deficiencies that are now represented by more than a dozen individual systems. Meanwhile, in parallel, H.07 is pursuing advanced, defensive threat alert and SA techniques for multiple transitions and insertions to mobility, SOF, and tactical aircraft—plus advanced on-/offboard sensor fusion techniques to aid offensive targeting and mission management functions.

The expanding, major EC push lies in the Suppression of Enemy Air Defense (SEAD) area—led by the Miniature Air-Launched Decoy (MALD) Program ACTD (H.04). A companion DTO from the DTAP begins advancing/adapting high-power microwave (HPM) techniques and technologies for the SEAD mission (WE.60.09). From the ES perspective, the new H.10 DTO builds on advancements in multispectral threat warning and undertakes advanced technology demonstrations of ES-based targeting for both "low/slow" platforms (rotary-wing aircraft and ground vehicles) and "high/fast" (fighter aircraft) platforms. Thus, the future lethal and nonlethal SEAD solution "set" is fully complemented by decoy, HPM, and ES sensor targeting options that will preemptively defeat integrated air defenses.

To augment the EW "triad" of the future (standoff communications jamming, SEAD, and standoff radar jamming), a joint development effort is being planned to design and develop the next-generation support jammer. Key to the program is the adoption of a reconfigurable/modular pod/UAV concept that will *not* depend on a dedicated airframe in the future, as is done today via the EA–6B. Synergies of the technologies involved will also have joint applications to affordable upgrades to jamming systems of all three services and their respective platforms (DTAP DTO WE.46.08, Coherent RF Countermeasures Technology, and H.06/H.08). H.06 is scheduled to end this year with demonstrated, major advancements for the RF self-protection of surface ship

combatants. Its completion will pave the way for its integration into the AIEWS program. On the other hand, H.08 is just underway and will tackle the tough monopulse threat to tactical aircraft via integration of advanced [classified] techniques and the insertion of modern, affordable technologies.

Figure XI–3 is a roadmap for developing and demonstrating the technologies required to support the operational advances in Electronic Combat. This roadmap concentrates on the themes of IRCM (air, land, and sea platforms); offensive C^2 warfare/information warfare; precision emitter location and battlespace SA; upgrades to our aging platforms; and the valuable "force multiplier" aspects of SEAD and support jamming.

F. SUMMARY

Figure XI–4 shows how this investment strategy will provide incremental improvements to Electronic Combat. This chapter presents a balanced approach to achieve platform protection and electronic support to all joint combatants. The plan emphasizes solutions to the formidable, worldwide IR missile threats; multispectral situation awareness; countering the C^2 hierarchies of the hostile force while preserving real-time knowledge of the enemy; and countering the enemy early in the engagement process via the EC triad of C^2 warfare, SEAD, and RF support jamming.

EC demonstrates vital support to the Chairman of the Joint Chiefs of Staff and his *Joint Vision 2010* concepts of Full-Dimensional Protection, Dominant Maneuver, and Precision Engagement. As an "enabler," EC demonstrates several, critical important synergies with the Information Superiority, Combat Identification, and Precision Force JWCOs, *with an overall focus on assuring survivability to the joint warfighter.*

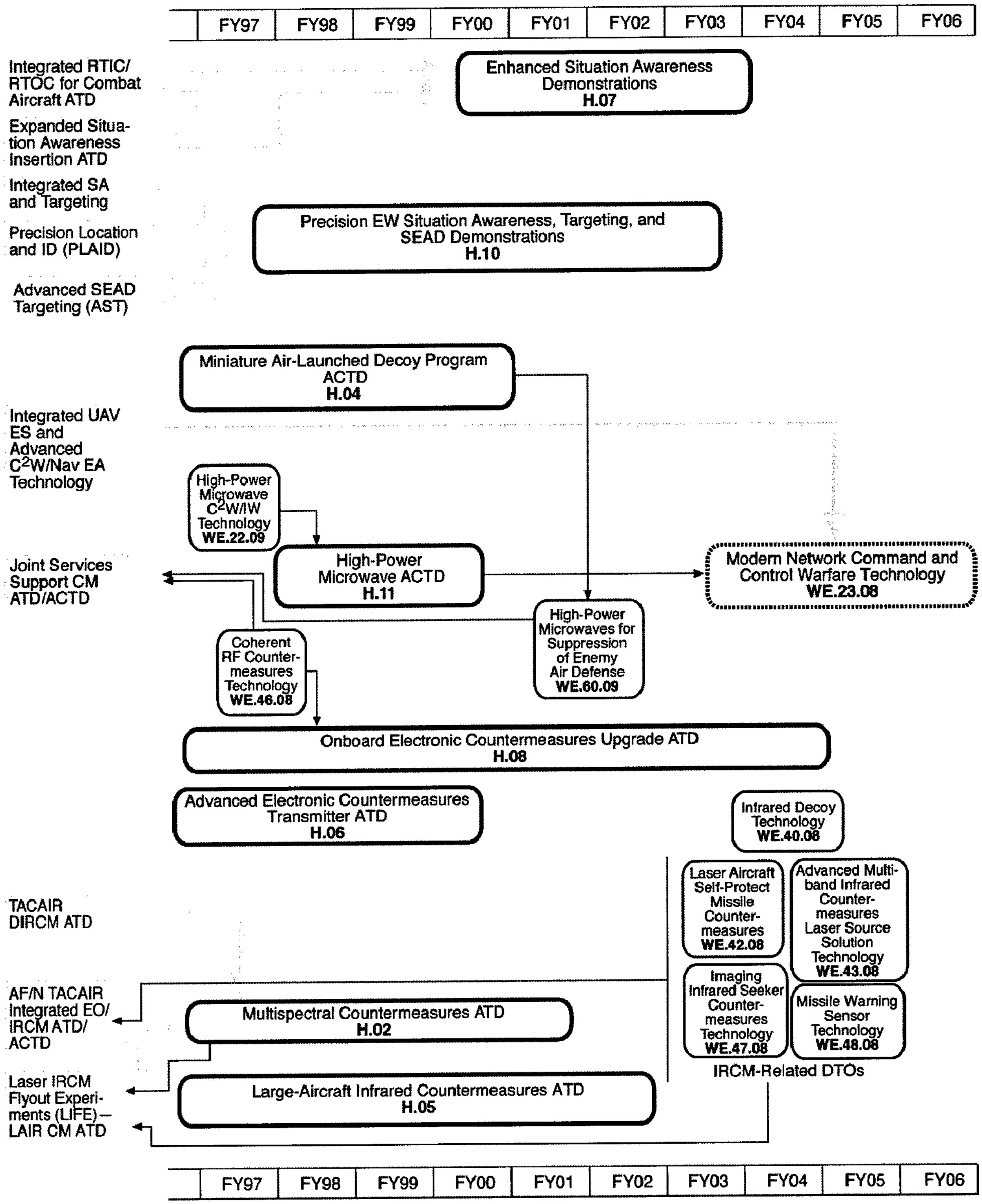


Figure XI–3. Roadmap—Electronic Combat

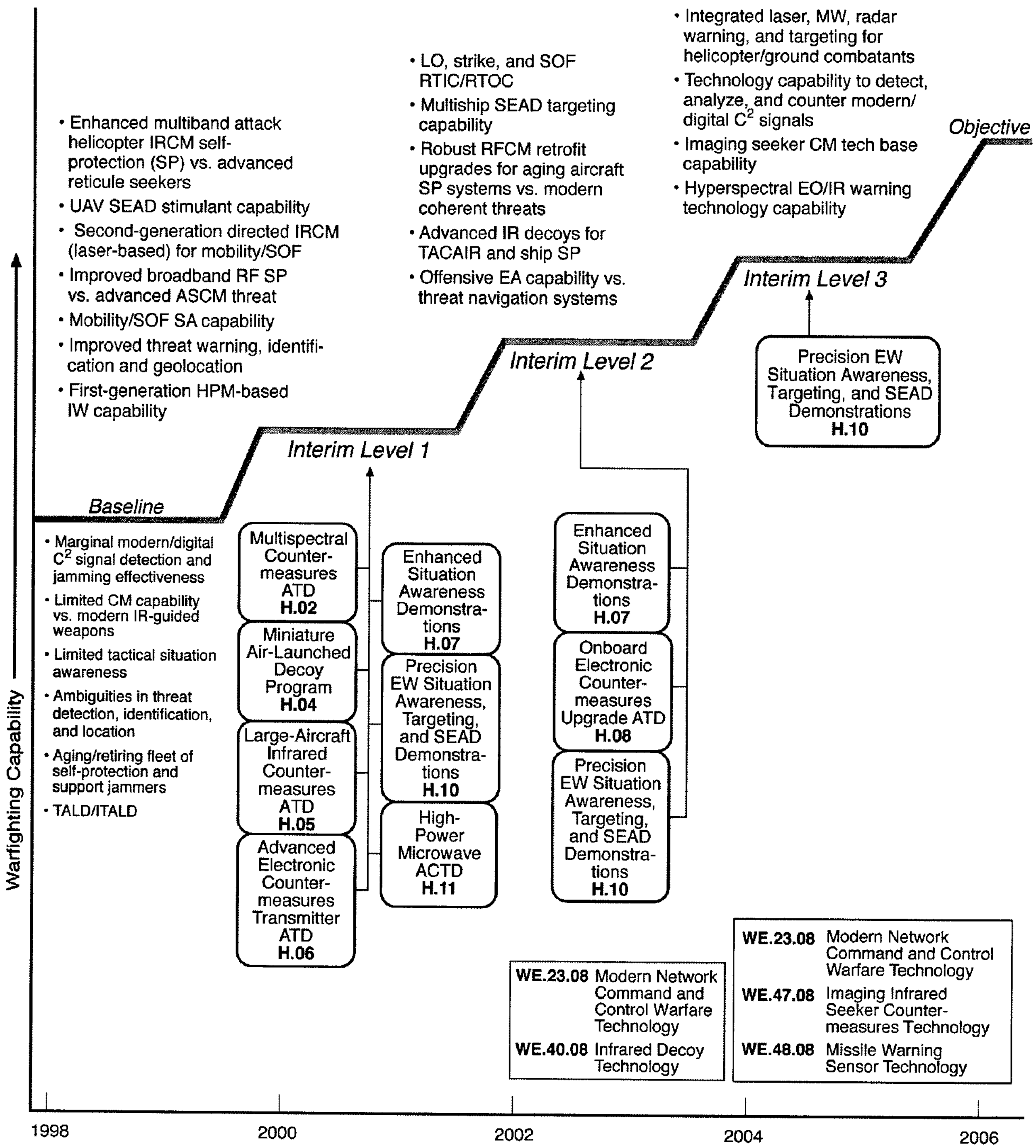


Figure XI–4. Progress—Electronic Combat

CHAPTER XII

CHEMICAL/BIOLOGICAL WARFARE DEFENSE AND PROTECTION AND COUNTER WEAPONS OF MASS DESTRUCTION

CHAPTER XII

CHEMICAL/BIOLOGICAL WARFARE DEFENSE AND PROTECTION AND COUNTER WEAPONS OF MASS DESTRUCTION

A. DEFINITION

1. Chemical/Biological Warfare Defense and Protection

Chemical/Biological (CB) Warfare Defense and Protection focuses on technologies to counter the threat of chemical and biological weapons, and to ensure the safety and mission effectiveness of U.S. forces operating in a contaminated environment with minimal impact on logistics. Contamination avoidance—to include the ability to detect, identify, characterize, and warn—is the highest priority of the DoD CB defense program. In addition to contamination avoidance, the program includes force protection (individual, collective, and medical) and decontamination.

2. Counter Weapons of Mass Destruction

Counter Weapons of Mass Destruction (CWMD) is the Joint Warfighting Capability Objective (JWCO) directed at counterproliferation. Key terms relevant to the DoD counterproliferation mission are defined in the adjacent box (Reference 21). While there are arguably differences in the terms *weapons of mass destruction (WMD)* and *nuclear, biological, and chemical (NBC)*, for the purposes of this presentation, WMD and NBC are used interchangeably.

Concepts for counterproliferation and chemical/biological defense are presented in Figures XII–1 and XII–2.

DoD Definitions

Counterproliferation (CP). The activities of the Department of Defense across the full range of U.S. Government efforts to COMBAT proliferation, including the application of military power to protect U.S. forces and interests; intelligence collection and analysis; and support to diplomacy, arms control, and export controls. Accomplishment of these activities may require coordination with other U.S. Government agencies.

Nonproliferation. The use of the full range of political, economic, informational, and military tools to *prevent* proliferation, reverse it diplomatically, or protect U.S. interests against an opponent armed with nuclear, biological, or chemical (NBC) weapons and the means to deliver them, should that prove necessary. Nonproliferation tools include intelligence, global nonproliferation norms and agreements, diplomacy, export controls, security assurances, security assistance, defenses, and the application of military force.

Nuclear, Biological, or Chemical (NBC) Weapons. Weapons that are characterized by their capability to produce mass casualties using NBC means and whose threat or use introduces individually diverse and distinct challenges to the planning and conduct of military operations.

Proliferation. The spread of NBC capabilities and the means to deliver them.

B. OPERATIONAL CAPABILITY ELEMENTS

1. Chemical/Biological Warfare Defense and Protection

The key operational capabilities in CB Warfare Defense and Protection are as follows:

- Contamination avoidance, including the ability to detect, identify, and warn of CB attacks.
- Protection, which encompasses individual, collective, and medical protection.
- Decontamination.

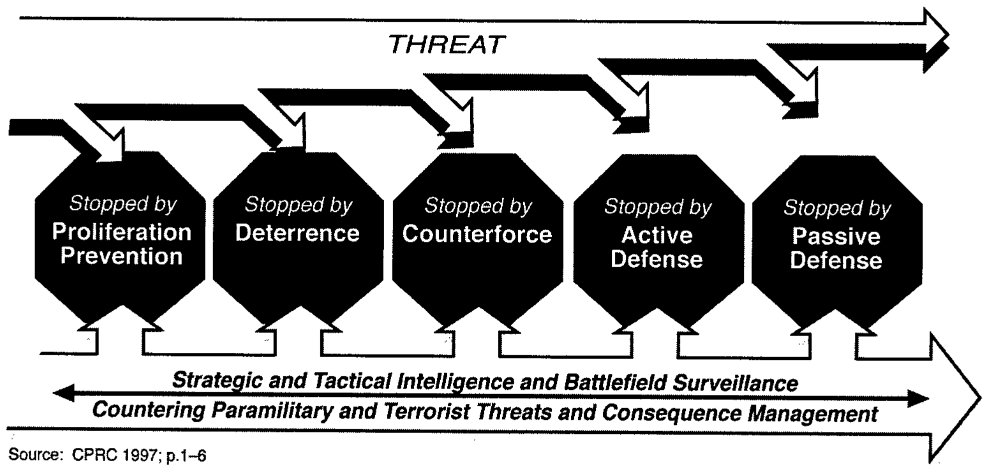


Figure XII–1. Concept—Counterproliferation

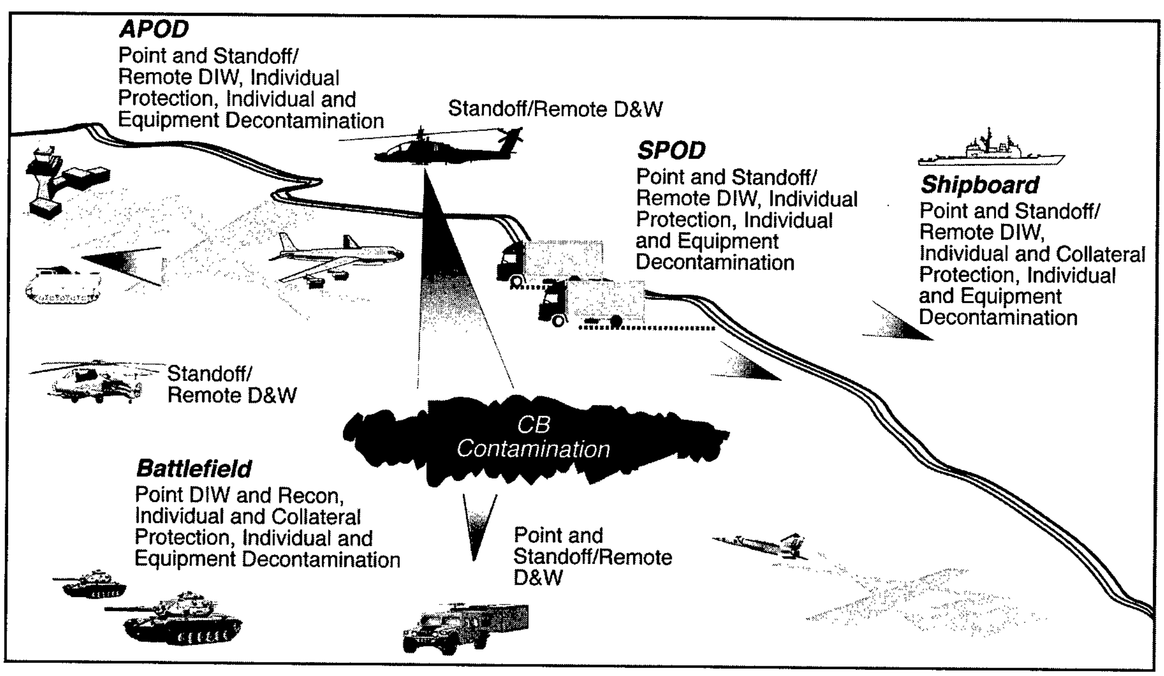


Figure XII–2. Concept—Chemical/Biological Defense

Figure XII–2 illustrates how CB Warfare Defense and Protection impacts all aspects of the battlefield, particularly in supporting the national 2 MTW global power projection strategy.

Operational capabilities for CB Warfare Defense and Protection are enhanced by the Defense Technology Objectives (DTOs) included in the JWSTP and DTAP. Technologies supporting these objectives will be refined through ACTDs, ATDs, and other technology demonstrations.

Contamination Avoidance. Technologies for the detection, identification, characterization, and warning of an attack are the cornerstone of defense against CB warfare. The key operational capability subelements are as follows:

- Early warning of a chemical/biological attack
- Point detection (or local warning) of a chemical/biological attack
- Warning and reporting of a chemical/biological attack.

Early Warning. Early warning of CB agents is key to the effective avoidance and protection against contamination. Early warning of a CB attack is a high JCS/CINC/JROC counterproliferation priority. Early warning, which complements local point detection, is intended primarily as a means of detecting and tracking chemical and biological agent clouds and providing information to commanders downwind that an attack has begun that involves agent released from a CB weapon. Intelligence capabilities provide information of an enemy's chemical or biological warfare capabilities (e.g., the size and nature of an enemy's stockpile). In contrast, early warning provides information as early during an attack as possible (from tens of seconds to tens of minutes before units are exposed to CB agent) so that commanders have increased options for operational responses, including which protective posture to assume. Early warning may be implemented through standoff detection using a variety of laser and passive optical detector technologies with a goal of ranges up to 100 km from the contamination, through point detectors deployed on remotely controlled platforms (e.g., unmanned aerial vehicles (UAVs)), or through the forward placement of point detectors (e.g., airdrops, Special Operations Forces (SOF) emplacement). While a single technology (or technology suite) with combined multiagent chemical and biological detection is a goal of these efforts, such a solution is not planned for transition out of technical base during the Future Years Defense Plan (FYDP). Current technology thrusts for early warning focus on separate systems for chemical and biological detection.

The most likely near-term approach will continue to rely on complementary detection technologies. For biological agents, current and near-term technologies seek to identify the presence of higher than normal concentrations of aerosols or particulate matter in the atmosphere. If these substances are present, data are examined to determine whether the aerosol/particulate formation is natural or manmade. Simultaneously, other sensors will seek to detect whether the aerosol or particulate contains biological material. If the material is biological, other sensors (e.g, a biological point identification system mounted on a UAV) may be deployed into the aerosol cloud to determine whether the material is a biological warfare agent. As technologies mature, new systems will be able to detect, identify, and characterize an increasing number of toxic agents, more reliably, and from greater distances. Technical barriers associated with developing these technologies include overcoming attenuation of laser energy by atmospheric absorbents and providing algorithms to discriminate between natural atmospheric species and biological agents.

One of the key DTOs—early warning of biological attack—has been transferred out of technical base and is being funded jointly by the Chemical/Biological Defense Program and the

Counterproliferation Support Program. This program seeks to provide maneuver forces, other forces at airbases and seaports, and (possibly) civilians in population centers with timely warnings of biological agents. Technologies being evaluated in an ACTD include standoff detectors and remote sensors.

Point Detection. The overall goal of point detection (also referred to as local warning) is to develop point sensor technologies that can rapidly detect the presence of CBW agents, identify these agents, and enhance the sensitivity, selectivity, reliability, and reduced size of CBW agent detectors. The program is divided into two parts—biological and chemical. Technologies under consideration in the near- and mid-term future cannot address both of these threats using the same technology. However, the goal is to develop a single suite of sensors to detect all potential CB threats. Chemical and biological detectors will be incorporated as separate modules and could be upgraded as newer technologies emerge. Understanding atmospheric propagation effects is important to this function. In addition to CB modeling efforts, these technologies apply to DTOs SE.52.01, Weather/ Atmospheric Impacts on Sensor Systems, and SE.53.01, On-Scene Weather Sensing and Prediction Capability.

Point detection improves visualization of CB hazards in a local environment through the exploitation of emerging technologies such as immunoassays, deoxyribonucleic acid/gene probes, various forms of spectroscopy, and other physical/chemical characterization technologies. The problems associated with this effort include (1) the development of sensor technology with sufficient sensitivity and discrimination that can detect, identify, and quantify the presence of biological and chemical hazards without false alarm, (2) antibody and DNA probe development to meet the emerging threat, and (3) the development and integration of C^3I technology to permit rapid, automatic collection, collation, dissemination, and display of CB hazard information to various command levels. Heretofore, the primary S&T focus has been in sensor development. However, it is becoming increasingly evident that new technologies are required to integrate sensor information with other battlefield situation awareness information (geographical, meteorological, intelligence) in order to properly design the software and hardware for the digital battlefield of the future.

The strategy for the biological detection technology effort is to develop a suite of complementary technologies to ensure that a capability in biological detection is achieved. Several technologies are currently being pursued in the Integrated Biodetection Advanced Technology Demonstration initiated in FY96. In addition, the JPO–BD sponsors a yearly field trial and evaluation of emerging technologies. The evaluation will provide recommendations to advance the development of relevant technologies, return immature technologies to the laboratory for additional development, or terminate the development of inadequate technologies.

The strategy for chemical detection is similar to that for biological detection. Currently there are two technologies being considered for a small system capable of individual warrior issue: ion mobility spectroscopy (IMS) and surface acoustic wave (SAW) devices. These are in a more mature state of development than biological detection technologies. An evaluation of the state of development and down selection between IMS and SAW technologies will be accomplished as the first phase of the FY98 contract for the Joint Chemical Agent Detector (JCAD). In addition, mass spectrometry is being examined for its applicability to both the chemical and biological detection problem.

Warning and Reporting. Warning and reporting is the critical link between CB detection and CB protection. The goal of this effort is to provide sufficient, accurate, and timely information to commanders at all levels through early and direct warning capabilities so they may develop options on how to conduct their mission and decide the appropriate protective posture to assume. Warning and reporting is a critical issue in contamination avoidance. The services have agreed to expedite development of this issue by integrating ongoing hardware and software into a Joint Warning and Reporting Network (JWARN) to be fielded in FY99. Technologies will be developed to provide increased management and control functions, as well as to integrate features of the emerging Global Command Control System (GCCS). The long-term goal of JWARN is to increase warning time by eliminating manual and voice transmission of data and replacing it with digital transmission, and providing significantly improved modeling and simulation capabilities to identify and predict the location and nature of CB hazards on the battlefield and to serve as a commander's decision aide.

Force Protection. The key operational capability subelements are Individual Protection, Collective Protection, and Medical Protection.

Individual Protection. The goals of individual protection technology efforts are to (1) improve protection against current threats and add protection against future threats, (2) minimize mission degradation by reducing the impact of the use of individual protection on the warfighters performance, and (3) reduce logistics burden. The key components of individual protection are ocular/respiratory protection and percutaneous protection. Both components support general warfighter requirements such as the Army's Land Warrior Program, as well as specialized applications for the Navy and Air Force. Advanced filtration technologies to reduce breathing resistance and selectively agent-impermeable membranes to increase uniform comfort will reduce individual performance degradation. Because of the high interest in providing protection against biological agents for both U.S. forces and their supporting civilian infrastructure in global force projection, initiatives will examine the feasibility of using lightweight, disposable biological masks against such hazards.

Collective Protection. The collective protection technology base efforts seek to maintain protection against current threats and add protection against future threats. At the same time, collective protection technology efforts seek to reduce logistical burdens through the development of improved filter materials with longer useable lifetimes. Collective protection efforts focus on (1) improvements to current reactive-adsorptive materials, (2) advanced nonreactive filtration processes, (3) advanced reactive filtration, (4) regenerable filtration processes for NBC protection of military vehicles, aircraft, ships, shelters, and buildings, and (5) reduced logistics burden.

Medical Protection. Medical protection consists of three primary functions: (1) pre-exposure preventative measures, (2) post-exposure treatment, and (3) diagnostic capabilities. These functions are applied to defense against chemical and biological threats. Technology efforts will provide a number of medical products for preventing illness or personnel degradation when percutaneous or aerosol CB agents are used on the battlefield. For personnel exposed to these agents, a number of initiatives will seek to ameliorate or preclude the effects of inhaled or percutaneous chemical agents or provide relief from the symptoms of biological agents. Current technologies only provide partial protection against a number of percutaneous or inhaled chemical agents, and only a limited number of vaccines are available against biological agents. Some specific treatments are available for exposure to a limited number of biological agents. Before effective treatment can be applied, the causative chemical or biological agent must be identified, at least by type.

Decontamination. Decontamination is defined as the process of removing or neutralizing a surface hazard resulting from a chemical or biological agent attack. The objective of decontamination technology efforts is to develop methods that are effective, are environmentally safe, react with chemical agents or disinfect biological agents, and do not impact the operational effectiveness of the surface or equipment being decontaminated. Current decontamination materials are caustic and rely heavily on water. Moreover, current methods for decontamination cannot be used to decontaminate critical areas at fixed site facilities, such as seaports or airports, the interiors of sea or air transport vehicles, or sensitive equipment, such as electronics and avionics. Critical studies are needed to define the decontamination technology issues that must be addressed as part of the national global force projection and our ability to simultaneously deploy in two potentially contaminated MTWs.

2. Counter Weapons of Mass Destruction

The critical elements of operational capability for proliferation prevention and counterforce are as follows:

- Timely target identification and characterization
- Prompt planning and execution of attacks
- Target defeat with minimized collateral hazards
- Combat and collateral hazard assessment.

Timely Target Identification and Characterization. Target identification and characterization are points on a continuum of information acquisition activities in support of counterproliferation. Identification occurs when NBC-related activities or capabilities are observed with enough specificity to support initial planning. For proliferation prevention, this might involve detection of attempts to develop or acquire NBC capabilities. For counterforce, this might involve determination that a specific facility is involved in production of NBC weapon materials or that NBC weapons are located at a specific site.

Characterization involves development of a more detailed description of the identified target. For proliferation prevention, this might involve identification of the most important elements in a proliferant state's attempt to develop or acquire NBC weapons to support direction of prevention activities against these critical nodes. For counterforce planning for use of conventional weapons against NBC targets such as production or storage facilities, detailed descriptions of the target are needed to allow weapons to be effectively directed against the key elements within the facility. Detailed target characterizations are also required to support planning to minimize collateral hazards.

The targets during proliferation prevention include capabilities for the production or use of NBC weapons plus the weapons themselves and supporting systems that are critical for their use. Many of the key technological capabilities required for development of biological, chemical, radiological, and (to a lesser extent) nuclear weapons are inherently dual-use and broadly distributed. Arms control measures may inhibit, but are unlikely to completely prevent, transformation of such proliferation potential into weapons.

For counterforce, the challenge is to promptly and accurately locate both NBC production capabilities and the locations of weapons, to include weapons and delivery systems that have already

been deployed. The Iraqi NBC programs illustrate how difficult target identification and characterization of NBC weapons and facilities can be. Since its defeat in the Gulf War, there have been onsite inspections in Iraq directed at these objectives. Even after several years of onsite inspections conducted by competent inspectors, the full scope of Iraq's programs was not appreciated until August 1995, when the defection of Saddam Hussein's son in law resulted in significant new information. The new disclosures included an intensive 1990 program that attempted to develop a nuclear weapon using nuclear fuel that should have been protected by international safeguards, manufacture of advanced chemical weapons, and a large-scale biological weapon program.

The challenges involved in defeating mobile missile launcher targets were also demonstrated during the Gulf War. A large number of aircraft sorties were directed at these targets. While this effort may have impacted Scud launcher operations by inducing the Iraqis to conduct fewer operations, Coalition aircraft were not successful in locating and destroying Scuds prior to launch (Reference 22).

For counterforce operations, consideration must be given to the different issues associated with three sets of NBC targets. These differences impact target identification and characterization, the effectiveness of conventional munitions for defeat of the target, and the collateral hazards that might be associated with attacks. In an attack using conventional weapons, the primary hazards may be due to the NBC materials being attacked (e.g., a conventional bomb attack may result in dispersion of NBC material, potentially over a large area). The primary NBC target sets addressed in counterforce planning (Table XII–1) involve:

- Fixed-facility targets located on the surface or shallow buried
- Deeply buried or otherwise hardened facilities
- Mobile targets (e.g., surface-to-surface missile launchers).

Specific goals, functional capability requirements, and shortfalls in capability vary across these three target sets. Target identification and characterization requirements vary from very short ranges (e.g., to support Special Operations Forces) to considerable distances for some potential target elements.

DoD R&D programs that develop, validate, and transfer technologies for effective monitoring and verification of arms control treaties and agreements are target identification and characterization in support of proliferation prevention objectives. The specific targets are potential treaty/agreement violations involving NBC military capabilities. Current programs provide support to treaties and conventions restricting development and deployment of nuclear, chemical, and biological weapons and associated production and delivery system capabilities. Because verification must be accomplished within an international political context, some of these development efforts are directed at producing results that can be released without compromising sensitive information collection capabilities. For example, DoD has developed a suite of equipment that can be used by international inspectors involved in verification of compliance with the Chemical Weapons Convention.

Prompt Planning and Execution of Attacks. NBC targets are often time critical. In proliferation prevention, only a limited window of opportunity may be available within which to prevent a key capability from being acquired. Counterforce operations conducted during a conflict are also

Table XII–1. NBC Target Sets

Target Sets Considerations	Fixed, On the Ground, or Shallow Buried	Fixed, Deeply Buried, or Otherwise Hardened	Mobile
Target Identification and Characterization Issues	In principle, the easiest set to identify. For extensive facilities, accomplishing the detailed characterization needed to identify specific NBC target nodes may be difficult. Some targets in this set were not correctly identified or characterized during the Gulf War.	Target identification and (particularly) characterization of facility targets and specific NBC-mission-related subelements are more difficult.	Camouflage, concealment, and deception (CCD) make it difficult to detect deployed missile launchers and, in some instances, deployed launchers. As explained in the Information Superiority JWCO chapter and demonstrated during the Gulf War, deployed mobile missiles are very difficult to locate and track.
Susceptibility to Defeat Using Current Conventional Weapons	Most targets can be defeated, in whole or part, using current weapons.	Some targets cannot be physically defeated using current conventional weapons; functional disruption (attacks that prevent operations from being accomplished) is the only practical targeting objective if conventional weapons are employed.	If promptly and accurately detected and target tracking is sustained for the period required, these targets can be defeated using current weapons.
Target-Induced Collateral Hazards	Collateral hazards can be significant and wide spread.	Collateral hazards may be significant; however, in some situations, the same target characteristics that impede defeat (e.g., deep burial) will also confine collateral hazards.	Local area collateral hazards may result; hazard magnitude depends on target characteristics and environmental conditions.

time critical. A target planning cycle that requires many hours (or days) may not respond to requirements. As is not the case in some other types of target planning for conventional munitions, there is a concurrent requirement for prompt, accurate assessment of the collateral hazards that might be associated with attack options that are under consideration.

Part of the needed response to these requirements involves development and validation of automated systems to support the planning and conduct of both prevention and counterforce operations. To ensure timeliness, emphasis is also given to the integration of these systems with other mission planning and communications capabilities. For proliferation prevention, there are additional requirements for technical capabilities enabling prompt, accurate collection and assessment of potential violations of treaties and norms restricting development and deployment of NBC weapons and production capabilities.

Target Defeat. Target defeat options vary along several dimensions. For all of the target sets, the optimum outcome is physical destruction of the target. In some situations, particularly for hardened targets, this is not a practical option, given the characteristics of currently available conventional munitions. This results in efforts to develop and validate new, more effective munitions. It also involves activities to enhance the usability of existing conventional systems (e.g., by providing increased capabilities for effective employment at night or during adverse weather conditions). Enhanced nuclear options have also been developed (e.g., the earth-penetrating B61–11).

Developing improved conventional weapons for defeat of chemical and biological threats is a specific priority. The objective is to completely destroy or otherwise neutralize chemical and biological agents. Shortfalls in current capabilities have been recognized and are being addressed

in current development efforts. Some of the improved agent defeat capabilities that are under development are intended for use by Special Operations Forces; a number these technologies also respond to the needs of first responder forces dealing with a BW or CW terrorist incident as described in Chapter XIII. Other agent defeat munitions are intended for delivery by aircraft or missiles.

For the foreseeable future, it will not be possible to physically defeat some NBC targets, particularly buried or otherwise hardened facilities, using standoff conventional weapons. In such circumstances, the targeting objective is functional disruption that prevents the target from accomplishing NBC missions. For example, the entrance to a tunnel facility might be attacked in ways that prevent mobile missile launchers from deploying to firing positions. This necessitates post-attack monitoring of the target facility and re-attacks to preclude resumption of operations.

For both physical defeat and functional disruption, the objective capability is to be able to defeat targets at times and under circumstances chosen by United States. This results in requirements for effective weapon systems that have the range required to reach targets and that are capable of penetrating defenses to reach targets. It also entails requirements for weapon systems that can accomplish missions during adverse environmental conditions.

Combat and Collateral Hazard Assessment. A range of consequences must be given consideration in counterproliferation mission planning and operations. These include prediction and mitigation of the collateral hazards that might result from:

- Attacks or strikes against NBC targets
- Enemy use of WMD against U.S., allied, or coalition forces during a major theater war
- Accidental or deliberate release of NBC agents from a facility.

A common set of technical capabilities provides the basis for accomplishing these tasks. Key factors include:

- Characterization of within-facility sources to develop an understanding of the potential hazards that might be dispersed
- Atmospheric transport modeling
- Real-time weather forecasting integrated with atmospheric transport modeling
- Accurate characterization of any hazards that might be produced
- Measures for mitigating NBC hazards
- Automated systems capable of providing target-specific and attack-option-specific assessments of both the hazards that might be associated with options and of the efficacy of methods for mitigating such effects
- Remote detection, tracking, and agent identification of the collateral effects resulting from a facility attack.

Force protection for U.S., allied, and coalition units will be a priority in mission planning.

There is a requirement for prompt, accurate determination of the effectiveness of an attack to support planning for re-attack options. The same technical capabilities are required for combat assessment (CA). For both CA and collateral hazard forecasting, automated systems must be

integrated with other planning support and communications capabilities to allow analysis and planning to be accomplished within demanding operational timelines.

Threat assessment is also important in proliferation prevention. Here the emphasis is on prompt, accurate detection of the signatures associated with violations of regimes prohibiting NBC weapons and their development (e.g., technical support for the Chemical Weapons Convention, development of the technologies needed for verification of a prospective Comprehensive Test Ban Treaty).

C. FUNCTIONAL CAPABILITIES

1. Chemical/Biological Warfare Defense and Protection

Table XII–2 shows the functional capabilities required to produce the operational capabilities composing chemical/biological defense and protection. Specific technology programs are listed under each functional capability.

2. Counter Weapons of Mass Destruction

The interrelationships between the critical functional capabilities and operational capability elements are depicted in Table XII–3. The elements within each functional capability are presented in Section D, Current Capabilities, Deficiencies, and Barriers.

Identification and Characterization Sensors. Information and characterization requirements and development priorities vary across the three target sets addressed in counterproliferation operations:

- Fixed, on the ground, or shallow buried
- Fixed, deeply buried, or otherwise hardened
- Mobile.

For all three sets, sensors must be capable of accurately and promptly detecting critical changes in target status (e.g., initiation of weapon-related activities at a fixed site; preparations for movement of mobile systems to the field; and, as occurred in Iraq immediately prior to the Gulf War, attempts to violate treaty commitments by attempting to develop a nuclear weapon using safeguarded nuclear materials). Because conventional munitions have a very limited radius of effectiveness, sensors must provide target information that has high resolution and fidelity. Given the limitations of potentially available signatures associated with these targets and activities, these are some of the most challenging DoD sensor development and application efforts. Range requirements vary from very short distances for SOF/First Responder operations to very long ranges for some attack options.

WMD Target Planning Tools. For counterforce applications, automated systems are needed to accurately process and analyze large volumes of information in near-real time. These tools must support analysis of complex targets and allow alternative targeting options to be developed and compared. The tool set must support appraisal of the collateral hazards that might be associated with attack options. Planning products must have connectivity to other tactical planning systems (e.g., systems that provide weather information). The objective is a suite of validated tools that seamlessly integrates with other tactical planning systems.

**Table XII–2. Functional Capabilities Needed—
Chemical/Biological Warfare Defense and Protection**

Functional Capabilities	Operational Capability Elements						
	Contamination Avoidance			Force Protection			Decontamination
	Early Warning	Point Detection	Warning and Reporting	Individual Protection	Collective Protection	Medical Protection	Force Sustainment
Chemical and Biological Detection Systems							
1. Chemical Point Detection		●					
2. Biological Point Detection		●					
3. Chemical Early Warning	●						
4. Biological Early Warning	●						
5. Warning and Reporting			●	○			
Modeling							
6. CB Modeling	●	●	○				
Protection							
7. Advanced Filtration Technology				●	●		
8. Advanced Materials for Percutaneous Protection				●			
9. Systems Integration				●	●		
10. Protection Assessment Technologies				●			
11. Advanced Protection for Unique Operations				●	●		
Decontamination							
12. Enzymatic Decontamination							●
13. DS2 Replacement Solution							●
14. Sensitive Equipment Decontamination							●
15. Sensitive Interior Decontamination							●
Medical Chemical Defense							
16. Vesicant and Respiratory Agent Therapy				●		●	
17. Advanced Anticonvulsant				●		●	
18. Multichamber Autoinjector				●		●	
19. Topical Skin Protectant				●		●	
20. Catalytic Scavenger/Nerve Agent Pretreatment				●		●	
21. Rapid Field Diagnostics				●		●	
Medical Biological Defense							
22. Aerosol Immunization Against Threat Agents				●		●	
23. Multivalent Vaccines				●		●	
24. Passive Vaccines (Monoclonal Antibodies)				●		●	
25. Rapid Field Diagnostics				●		●	

● Strong Support ○ Moderate Support

**Table XII–3. Functional Capabilities Needed—
Counter Weapons of Mass Destruction**

Functional Capabilities	Operational Capability Elements			
	Timely Target ID and Characterization	Prompt Planning and Execution of Attacks	Target Defeat With Minimized Collateral Hazards	Combat and Collateral Hazard Assessment
1. Identification and Characterization Sensors	●	○		●
2. WMD Target Planning Tools	○	●		●
3. Sensor Data Fusion	●	●		●
4. WMD Proliferation Path Analysis	●	●		●
5. Real-Time Weather Data and Forecasts	●	●	○	●
6. Collateral Effects Prediction		●		●
7. Enhanced Penetrating Munitions		●	●	
8. Enhanced Lethality Warheads		●	●	
9. Agent Defeat Payloads			●	
10. Hard-Target Smart Fuzing		●	●	
11. All-Weather Guidance		●	●	
12. Combat and Collateral Hazard Sensors		○		●
13. Survivability	●	●	●	●
14. Preventive Defense	●	●	●	●

● Strong Support ○ Moderate Support

For defeat of mobile NBC targets, qualitatively improved capabilities are needed. These include the automated support required for continuous monitoring of data developed by multiple sensors using different phenomenologies; near-real-time integration and evaluation of this information in environments in which camouflage, concealment, and deception (CCD) is likely; and the ability to bring attack systems to bear in the limited time windows within which surface-to-surface missiles (SSMs) and other NBC mobile targets are most vulnerable. Most of these capabilities are under development in programs that respond to multiple requirements for defeat of mobile targets.

For proliferation prevention, proliferation path assessment tools are needed to identify critical nodes within the ensemble of capabilities that support NBC proliferation. This capability is essential to allow monitoring, verification, export control, and other activities to be appropriately focused.

Near-real-time responsiveness is required for all facets of counterforce and proliferation prevention. Critical changes in status such as diversion of materials or movement of SSMs to the field must be promptly detected and responded to.

Sensor Data Fusion. Multiple sensors based on different phenomenologies are directed at all of the counterproliferation target sets. These data streams vary along multiple dimensions, which include:

- Militarily relevant characteristics that can be identified
- Susceptibility to CCD and countermeasures
- Platform availability during major theater war scenarios in which there are many more requirements than available assets
- Time-stamping—some sensors (e.g., aerial photography) may provide intermittent observation; others may provide continuous 24/7 coverage (24 hours a day, 7 days a week).
- The amount of time and level of effort required for processing raw sensor data into usable information.

Greatly improved capabilities for automated transmission, integration, and analysis are required to support counterforce applications. Traditional stovepipe approaches in which separate data streams are sent to a command center are not responsive to requirements.

WMD Proliferation Path Analysis. Proliferation paths are the sequence of capabilities and actions whereby potential antagonists acquire NBC weapons and their means of delivery (NBC/M). Automated systems are needed to support proliferation path analysis, both to manage the large volume of disparate types of data that must be collected and analyzed and to develop a valid model of the emergent (or in-place) NBC military capability. For proliferation prevention, this capability allows activities to be more effectively focused; for counterforce, it assists in identifying the key elements that need to be defeated.

Real-Time Weather Data and Forecasts. In counterforce planning, two sets of requirements for real-time weather data and forecasts are needed. The first involves target planning. The effectiveness of some current delivery platforms and weapon systems is influenced by weather conditions. Hence, potential environments must be given consideration when attack options are under development. The second requirement is to support collateral hazard prediction and mitigation. Weather in the target area has a very significant impact on atmospheric transport.

Collateral Effects Prediction and Mitigation. A priority here is development of improved automated systems for collateral hazard forecasting that can be operated in field command centers by nontechnical personnel. This capability must be integrated with the other systems that support tactical planning, and must interface with existing C^4I (e.g., to receive weather updates). The state of the art in fieldable automated systems that can be effectively employed by nontechnical personnel has increased tremendously in recent years. However, there are limits as to what can be deployed in the field and used by operational forces. Hence, a second thrust uses CONUS-based DoD high-performance computing resources to develop and validate advanced models for collateral hazard prediction. In addition to providing results that can be applied in successive generations of fieldable systems, this capability can also support operations from CONUS in direct technical support for hazard prediction, as was done during the Gulf War.

Enhanced Penetrating Munitions. Improved penetrating munitions are needed for counterforce missions. Conventional munitions have a limited radius of effects. To defeat many NBC target elements, it is necessary to have the conventional munition detonate in proximity to the target. It is also the case that NBC target structures are hardened to varying degrees. Damage inflicted on the structure may or may not have any mission-critical impact on the NBC capabilities located within.

Enhanced penetrating munitions make it possible to deliver warheads where they can have the needed effects. The objective is optimized detonation location regardless of target hardness.

Enhanced Lethality Warheads. Some warheads in the current conventional weapons inventory do not have sufficient lethality for decisive defeat of all NBC targets. This is exacerbated when penetrating munitions are required for the mission. An aircraft may be capable of carrying a 2,000-pound munition on a hard point. The features that make the weapon capable of penetrating into a structure necessarily add to the weight of the munition; significant increases in warhead lethality may be needed simply to have the same lethality as a nonpenetrating munition of the same weight. In some situations, collateral hazard considerations may also impact choice of munition.

Agent Defeat Payloads. Most NBC targets contain significant quantities of extremely hazardous materials. In a conventional attack against such targets, collateral effects may be target (rather than weapon) induced. For example, an attack against a CW or BW storage or production facility might result in dispersal of hazardous agents over a large area. Similar considerations hold for nuclear targets. Threats must be countered both within the United States and in potentially hostile environments; the types of weapons and facilities that must be defeated (or penetrated in order to accomplish defeat) vary; different options are appropriate for delivery by weapon systems versus SOF. Additional nonnuclear options that provide options for limiting collateral hazards are desirable.

Hard Target Smart Fuzing. Conventional weapons have a limited radius of effects. Hard target smart fuzing uses void sensing or other technologies to delay detonation of a conventional munition until it has penetrated into a target structure and is in closer proximity to critical target elements.

All-Weather Guidance. Some delivery systems and weapons cannot be used in all weather conditions or have their accuracy degraded in some environmental conditions. All-weather guidance is needed to enable 24/7 availability of these options.

Combat and Collateral Hazard Sensors. There are situations in which it can be difficult to assess the effectiveness of an attack, given the limits of current sensors (e.g., when a penetrating munition detonates inside a large facility or within an underground structure). The absence of reliable CA information may require forces to conduct unnecessary re-attacks, thus placing them at risk, and divert sorties from other priority missions.

Survivability. The ability to withstand NBC and other threats is a necessary condition for the accomplishment of counterforce missions. For both proliferation prevention and counterforce, survivability has strategic significance. One of the potential incentives for acquisition or use of NBC weapons is as an "asymmetric counter" to offset the United States' conventional superiority. Deployment of forces capable of withstanding such proliferant threats reduces incentives for acquisition or use of NBC as an asymmetric counter.

Preventive Defense. Preventive defense supports proliferation prevention through measures to ensure that NBC weapons and production capabilities are not at risk of diversion. It encompasses cooperative threat reduction and technical and operational support for verification of arms control agreements.

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

1. Chemical/Biological Warfare Defense and Protection

Table XII–4 presents the key technologies being pursued to overcome current operational limitations in the functional capabilities that compose CB Defense.

Table XII–4. Goals, Limitations, and Technologies—Chemical/Biological Warfare Defense and Protection

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Chemical Point Detection			
Provide small, lightweight, rapid detection and characterization of all threat agents.	Single chemical point detector for all warfighting and support applications (e.g., troops, aircraft, ships, vehicles, SOF)	No mustard agent detector Detectors are not sufficiently miniaturized	Miniature detectors IMS, SAW, and other technologies with agent concentrator
Operational Capability Element: Biological Point Detection			
Provide rapid, all-agent detection and characterization.	Single biological point detection for all warfighting applications	No portable systems Limited number of agents No rapid detection Inadequate sampling and collection systems	Lightweight detector Near-real-time detection Non-agent-specific hazard identification (neuro-based sensor)
Operational Capability Element: Chemical Early Warning			
Provide lightweight, on-the-move detection (field of view 360° wide x 60° high). Provide high-value site defense.	Low-cost, lightweight vehicle capability for contamination avoidance Vapor, aerosol, and liquid agent detection for ships and air bases	No on-the-move detection capability Vapor detection only No miniaturized systems No unattended sensors	FTIR with moving background algorithm DISC/DIAL Coherent frequency agile laser Remotely employable technologies
Operational Capability Element: Biological Early Warning			
Provide early warning of biological attack Provide tracking of threat agent clouds	Safe to operate Single system for aircraft, vehicle, ship, and fixed-site defense	Not eye safe Aerosol cloud detection only	Eye-safe laser Wideband, tunable laser for agent identification
Operational Capability Element: Warning and Reporting			
Provide fully integrated, interoperable, joint service, real-time warning, reporting, and mapping of all CB hazards.	Automatic warning and reporting to entire force up to theater command level	Manual Voice, radio, and paper reports Not integrated into GCCS	Automatic radio relay Automatic NBC report preparation Computer mapping with rapid, near-real-time updates

**Table XII–4. Goals, Limitations, and Technologies—
Chemical/Biological Warfare Defense and Protection (continued)**

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Individual Protection			
Protect force from CB contamination and ensure ability to sustain operations and accomplish mission in a CB contaminated environment.	Common individual protection equipment (IPE) design and material for services' applications with modular adaptation for ground, sea, and air (same system—different packages) Reduced performance degradation Assured integration/ compatibility with future equipment	Significant improvements in respiratory protection are not likely in near future without a material (filter) breakthrough or using a powered system Ability to satisfy final performance goals may require multiple systems or power as in case of thermal degradation Full definition of 21st century Land Warrior is needed to satisfy future compatibility requirements Attempting to use one mask for all joint service missions may result in performance reductions for some missions Mission requirements for weight, protection, and launderability force tradeoffs; no single material fulfills all requirements Requirements for protection and tactility for gloves force tradeoffs Promising materials for percutaneous protection do not meet affordability requirements; unsuitable for mass production	New concepts in respiratory protection: enhanced protection studies; material and composite technologies Protective system integration and analysis: quantification of mission performance; performance testing; performance models for predicting current and future equipment Protective material and test technologies: improvement of test methodology for protection assessment; improvement of aerosol stability; investigation of effects of different aerosol sizes on protection New/improved filtration systems: development of engineered adsorbent—superactivated adsorbents and polymeric adsorbents; new catalytic systems will be developed; improved particulate filtration technologies Focus on unique operational aspects of marine environment, such as firefighting/damage control, flight deck operations, and high-intensity SPECWARS operations Selectively permeable materials for percutaneous protection Various reactive and nonreactive lightweight materials and membranes for protection against all identified CB hazards Novel elastomers for overboot protection
Operational Capability Element: Collective Protection			
Ensure ability to sustain operations and accomplish mission in a CB contaminated environment.	Regenerable (catalytic) filtration to reduce logistics burden while increasing protection factor Reduction in weight, cube, and power requirements	Basic research funding limited to understand link between physical and adsorptive properties of various materials to predict and optimize filtration performance No adequate means to measure filter life in the field No clearly defined requirements for collective protection	Reactive-adsorptive materials Advanced nonreactive filtration processes Advanced reactive filtration processes for NBC protection of military vehicles, aircraft, ships, shelters, and buildings Regenerative filtration processes (pressure- and temperature-swing adsorption, PSA/TSA) Embedded monitors Plasma technologies Catalytic oxidation (CATOX)

Table XII–4. Goals, Limitations, and Technologies—Chemical/Biological Warfare Defense and Protection (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Medical Chemical Defense			
Maintain technological capability to meet present requirements and counter future threats; provide individual-level prevention and protection to preserve fighting strength; provide medical management of chemical casualties to enhance survival and expedite and maximize return to duty.	Training of health care providers in treatment of chemical casualties Nerve agent pretreatment and therapy Antiseizure therapy Rapid deployment teams for assessment, training, treatment, and evacuation Advanced development of topical skin protection Advanced development of nerve agent field diagnosis Advanced development of cyanide prophylaxis	Need for expansion of chemical/biological medical training program Advanced product development and FDA approval process for fielding of chemical products Current downsizing and monetary restrictions Integration of DoD/tri-service needs (better joint coordination and representation)	Vesicant and respiratory agent therapy Advanced anticonvulsant Multichamber autoinjector Reactive topical skin protectant Topical optical treatment Catalytic scavenger treatment for chemical agents Advanced nerve agent pretreatment
Operational Capability Element: Medical Biological Defense			
Sustain effectiveness of U.S. armed forces operating in a BW environment: • To prevent casualties by use of medical countermeasures • To diagnose disease with forward deployable kits and confirmation assays • To treat casualties to prevent lethality, and to maximize return to duty.	Training of health care providers in prevention and treatment of biological casualties Anthrax immunization prophylaxis Botulinum toxin immunization Smallpox immunization Use of other commercially available vaccines if necessary (e.g., cholera, plague, tularemia, Q-fever, encephalitis virus, etc.) Rapid deployment teams for assessment, treatment, and evacuation	Need for expansion of CB medical training program Length of time for FDA license and approval of new and existing biological agent vaccines Current downsizing and financial restructuring Need for greater integration of DoD/tri-service (better joint coordination and representation) Rapid stockpiling of vaccines identified by threat priority	Aerosol immunization against biological threat agents Multivalent vaccine against biological threat agents Pretreatment against biological threat agents Rapid field diagnostics
Operational Capability Element: Decontamination			
Ensure ability to sustain operations and accomplish mission in a CB contaminated environment.	All-agent, noncorrosive, less labor intensive decontamination capability DS2 replacement Decontaminant suitable for aircraft, ship, and vehicle interiors, and sensitive items Prevention of effects of CB agents on materials; NBC survivability technology Determination of requirements for large-area decontamination Identification of effective measures for containing CB contamination	Current decontaminant is effective in chemical decontamination, yet has surface corrosive effect Limited assessments have been made to determine scope of problems associated with the restoration of operations at fixed sites; consequently, there are no formal requirements Environmental and safety requirements limit choice of decontaminants Assessment of methods and technologies to decontaminate compartment interiors needed	Environmentally safe decontamination of electronic and sensitive equipment Sorbent technology Dissemination techniques and technologies Spectroscopic techniques Enzymatic decontamination Reactive chemical processes Catalytic chemical processes Supercritical fluid extraction Gas phase ozone oxidation

For *point detection*, the technological issues are (1) development of real-time detection of biological materials (current capabilities require 30 minutes to detect and identify biological agents); (2) unique identification of biological materials; (3) improved sampling and collection technologies for warfare agents; (4) small, lightweight chemical detector (current capabilities provide detection for units but are not useful for use by an individual); and (5) decrease in false alarm rate.

For *early warning*, the technological issues are (1) discrimination of biological warfare agents from each other and from naturally occurring biological materials in the atmosphere; (2) size, weight, and power requirements of chemical and biological detection systems (meeting these constraints may require tradeoffs in range and sensitivity); (3) aerosol background (naturally occurring biological materials such as pollen may cause high false alarm rates for biodetection systems); (4) man–machine interface; (5) sensor integration on various platforms (e.g., UAVs); (6) on-the-move standoff detection of chemical and biological agents; and (7) sensitivity of standoff detection systems.

For *warning and reporting*, the technological issues are (1) digitization of battlefield sensor information; (2) automation of detection and warning processes; (3) collation and display of relevant information at various command levels; (4) integration of other sensor information such as geolocation and meteorology; and (5) integration of data into appropriate models for analysis and presentation.

For *individual protection*, the technological issues are (1) development of materials that reduce heat and other stress burdens on the soldier and are more selective in precluding transport of agents across the ensemble barrier but pass heat and perspiration; (2) provision of clear criteria for dexterity, tactility, and mobility requirements; and (3) provision of masks that can be adapted to a number of specialized aircrew applications.

For *collective protection*, the technological issues are (1) development of longer lifetime filters/filter materials for collective protection shelters and (2) development of regenerative filter processes and materials.

For *medical protection*, the technological issues are (1) development of vaccines against remaining threat list biological agents; (2) development of FDA-acceptable testing protocols for vaccines to determine vaccine efficacy; (3) development of improved topical skin decontamination material; and (4) development of prophylaxes against nerve agents and vesicants.

For *decontamination*, the technological issues are (1) development of an environmentally safe, rapid acting, less corrosive, nonaqueous-based decontamination material; (2) development of technologies and operational doctrine for restoration of operations at critical areas of fixed site facilities such as seaports and airports; (3) provision of technologies for decontamination for sensitive closed areas (such as cargo holds or ship compartments) and sensitive equipment (such as electronics and avionics); and (4) development of standards for low-level, long-term exposure to CW agents.

2. Counter Weapons of Mass Destruction

Table XII–5 shows interrelationships between the operational and functional capabilities and goals, limitations (shortfalls in capability), and technology requirements.

Table XII–5. Goals, Limitations, and Technologies— Counter Weapons of Mass Destruction

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Timely Target Identification and Characterization			
Identify, locate, monitor/track, and characterize three NBC/M target sets: • Fixed, surface or shallow buried • Fixed, deeply buried or hardened • Mobile	Identification and characterization sensors WMD target planning tools Sensor data fusion WMD proliferation path analysis Combat assessment sensor Survivability Preventive defense	Limited sensor capabilities for critical mission tasks: • Tracking mobile targets • Detecting changes in status or activities within fixed facilities • Characterization of large or deeply buried facilities Sensor data stream stovepipes not sufficiently integrated with target planning capabilities Inadequate integration and analysis of all-source intelligence Information not sufficiently timely Poor understanding of proliferant-specific paths toward acquisition of NBC/M and of current status on paths; limited capability to manage and analyze large volumes of data Limited ability to assess consequences of attack, particularly for buried or large targets or when objective is functional disruption Increased use of commercial electronics and systems for sensors and C^4I that may be susceptible to defeat or disruption by electromagnetic effects Some sensor information cannot be promptly processed	Weapon-borne sensor to support target characterization and CA Modified tactical forward-looking infrared sensor for plume signature CA Advanced SAR/radar imaging Unattended ground sensors with seismic, acoustic, electromagnetic, and NBC capabilities Multisensor imaging and fusion Remote BW/CW sensors Low-cost and man-portable sensors Microsensors Real-time data fusion/integration ATR and automated handling of massive data streams Automated proliferation path analysis for critical node identification Long-wave EM detection of underground structures Specific emitter identification Seismic, chemical, and other verification technologies
Operational Capability Element: Prompt Planning and Execution of Attacks			
Develop operationally suitable, integrated, computerized force application recommendations with confidence bounds and collateral effects/predictions/minimization for WMD targets. The objective is a target planning capability for counterforce that is seamlessly integrated with other mission planning and C^4I capabilities. For proliferation prevention, provide capability to rapidly process information in formats and on timelines that are responsive to mission requirements.	Identification and characterization sensors WMD target planning tools Sensor data fusion WMD proliferation path analysis Real-time weather data and forecasts Collateral effects prediction Enhanced penetrating munition Enhanced lethality warhead Agent defeat Hard target smart fuzing All-weather guidance Survivability Preventive defense Combat and collateral hazard sensors	No decision aid to determine where in WMD development, production, and employment process counterforce attacks have highest probability of success and minimum collateral effects Shortfalls in targeting calculation capabilities, including: • Soft, bermed, cut-and-cover, and deeply buried targets • Structural response and functional kills of internal equipment • Restrike decision based on CA • Tunnel portal and adit disruption • Advanced conventional/enhanced weapon payloads • Optimization to minimize collateral effects • Real-time weather data input	Computational physics and experimental assessments of weapon–target interactions Advanced (HPC) computational capabilities Significant improvements in capabilities for predicting collateral hazards Collateral effects modeling that takes advantage of the best available real-time weather data Automated systems capable of integrating proliferation path inputs

Table XII–5. Goals, Limitations, and Technologies— Counter Weapons of Mass Destruction (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Target Defeat With Minimized Collateral Hazards			
Acquire means to defeat NBC/M targets at times and under circumstances chosen by the United States.	Enhanced penetrating munition Enhanced lethality warheads Agent defeat (validated methods/ warheads) Hard-target smart fuzing All-weather guidance Survivability Preventive defense	No available earth penetrator that can destroy deeply buried or very hard WMD targets No earth penetrator with payloads for BW/CW agent defeat or neutralization Limited, highly accurate, all-weather delivery capability No subsurface CA No real-time, all-source data fusion	Advanced penetrating weapons Void-sensing, depth-sensing fuze Highly accurate, all-weather guidance/delivery Weapon-borne sensor to provide penetration/detonation history High-temperature incendiary and BW/CW agent defeat payloads Real-time, all-source sensor data fusion Sensors that provide capability for in-transit detection of NBC/M
Operational Capability Element: Combat and Collateral Hazard Assessment			
Develop an operationally suitable, integrated all-weather WMD source/ transport/effects prediction capability for effects on military forces and civilian populations resulting from (1) accidental release from WMD facility, (2) enemy use of WMD, or (3) U.S. attack on WMD or related facility. Develop means to minimize collateral effects resulting from U.S. attack on WMD or related facility.	Identification and characterization sensors WMD target planning tools Sensor data fusion WMD proliferation path analysis Collateral effects prediction Agent defeat Battle damage assessment sensor Survivability Preventive defense	No integrated, automated, and validated NBC hazard prediction tools for wide-ranging WMD targets and U.S. weapons No sensors and tools able to provide detailed equipment, enemy WMD, and WMD facility characterization No special weapons that achieve functional kill while minimizing NBC release Shortfalls in remote/standoff sensors for detection and characterization of BW/CW agents	Weapon-borne sensor to provide penetration/detonation history Accurate models for expulsion of NBC materials High-resolution, in-theater, real-time weather data and forecasts Accurate models for terrain effects on transport in NBC models Lethality assessment of dispersed NBC materials Targeting methods and advanced weapons to minimize expulsion of NBC materials Sensors and tools for WMD facility, equipment, and enemy WMD weapon characterization Real-time, all-source sensor data fusion

E. TECHNOLOGY PLAN

1. Chemical/Biological Warfare Defense and Protection

Technology demonstrations and joint field trials provide a means for the rapid field testing of technical options to solve operational needs. These demonstrations support the CB Warfare Defense and Protection JWCO. Table XII–6 lists the DTOs that, when attained, will enable the operational capabilities to meet the CB defense objective of the JWCO. Table XII–7 illustrates how these demonstrations and supporting technologies are structured to support the JWCO. The DTOs supporting the operational capability elements are shown in Figure XII–3. Each DTO is described in the *Defense Technology Objectives of the Joint Warfighter Science and Technology Plan* (Reference 6) and the *Defense Technology Area Plan* (Reference 3). Relationships among DTOs are plotted in the technology roadmap, Figure XII–4. Figure XII–5 provides a notional path for the contribution of each DTO toward the overall CB Warfare Defense and Protection goals of the JWCO.

**Table XII–6. Defense Technology Objectives—
Chemical/Biological Warfare Defense and Protection**

DTO No.	Title
I.02	Joint Biological Remote Early Warning System ACTD
I.03	Airbase/Port Biological Detection ACTD
I.04	Integrated Biodetection ATD
I.05	Chemical Enhancement to the Airbase/Port Biological Detection ACTD
L.07	Terrorist Chemical/Biological Countermeasures
CB.02.10	Joint Warning and Reporting Network
CB.06.12	Advanced Lightweight Chemical Protection
CB.07.10	Laser Standoff Chemical Detection Technology
CB.08.12	Advanced Adsorbents for Protection Applications
CB.09.12	Enzymatic Decontamination
CB.16.12	Enhanced Respirator Filtration Technology
CB.19.01	Chemical Imaging Sensor
MD.04.J00	Medical Countermeasures for Botulinum Toxin
MD.05.J00	Chemical Agent Prophylaxes
MD.07.J00	Medical Countermeasures for Vesicant Agents
MD.13.J00	Medical Countermeasures for Staphylococcal Enterotoxin B
MD.14.J00	Medical Countermeasures for *Yersinia pestis*
MD.15.J00	Medical Countermeasures for Encephalitis Viruses
MD.16.J00	Multiagent Vaccines for Biological Threat Agents
MD.17.J00	Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases
SE.38.01	Microelectromechanical Systems

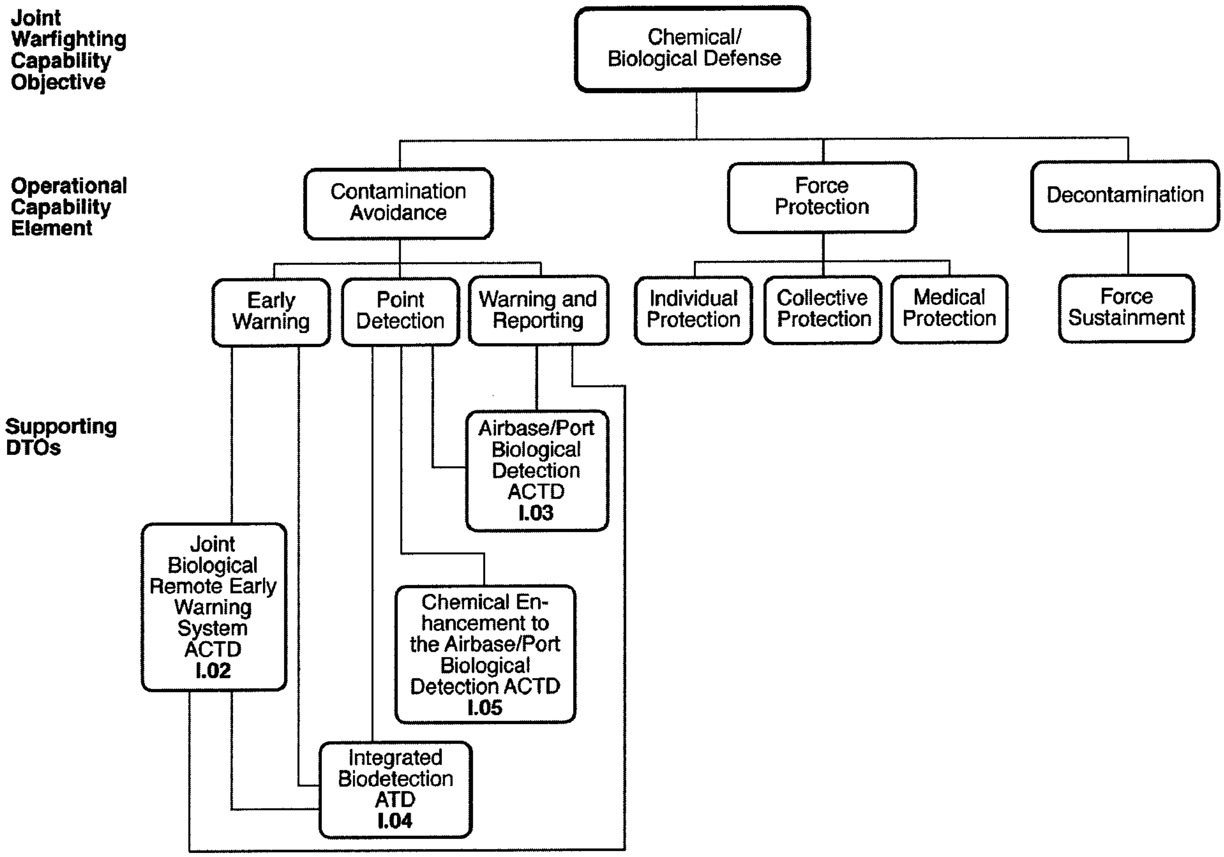
Below is a brief description of each JWSTP CB Warfare Defense and Protection DTO:

- *I.02, Joint Biological Remote Early Warning System ACTD*, will evaluate the military utility of remote early warning for biological warfare attacks against U.S. forces and to develop the operational procedures and doctrine associated with that capability. An additional objective is to provide the CINCs an interim residual capability to detect and provide automated warning and reporting to promptly alert those forces that may be exposed to biological warfare agents.
- *I.03, Airbase/Port Biological Detection ACTD*, will demonstrate a biological local warning capability and operational procedures to detect, alarm, warn, dewarn, identify, protect, and decontaminate fixed sites such as airbases and seaports of embarkation against a biological warfare attack.
- *I.04, Integrated Biodetection ATD*, will demonstrate technologies that provide a pre-exposure warning for a biological attack and that provide an order-of-magnitude increased sensitivity to agents while adding a first-time virus identification capability with significantly reduced logistics.
- *I.05, Chemical Enhancement to Airbase/Port Biological Detection ACTD*, will demonstrate an integrated biological and chemical detection and warning capability at an airbase or port facility.

Table XII–7. Demonstration Support—Chemical/Biological Warfare Defense and Protection

	Operational Capability Elements								Type of Demonstration		
	Contamination Avoidance			Force Protection			Decontamination				
Demonstration	Early Warning	Point Detection	Warning & Reporting	Individual Protection	Collective Protection	Medical Protection	Force Sustainment	Service/ Agency	DTO	ACTD	ATD
Joint Biological Remote Early Warning System ACTD	●	○	●					Joint	I.02	X	
Airbase/Port Biological Detection ACTD		●	●	○				Joint	I.03	X	
Integrated Biodetection ATD	●	●						Joint	I.04		X
Chemical Enhancement to the Airbase/Port Biodetection ACTD		●	○					Joint	I.05	X	
Terrorist Chemical/Biological Countermeasures						○	○	Joint	L.07		
Joint Warning and Reporting Network	●	●	●					Joint	CB.02.10		
Advanced Lightweight Chemical Protection				●				Joint	CB.06.12		
Laser Standoff Chemical Detection Technology	●							Joint	CB.07.10		
Advanced Adsorbents for Protection Applications				●	●			Joint	CB.08.12		
Enzymatic Decontamination							●	Joint	CB.09.12		
Enhanced Respirator Filtration Technology				●	○			Joint	CB.16.12		
Chemical Imaging Sensor	●							Joint	CB.19.01		
Medical Countermeasures for Botulinum Toxin				●		●		Joint	MD.04.J00		
Chemical Agent Prophylaxes				●		●		Joint	MD.05.J00		
Medical Countermeasures for Vesicant Agents				●		●		Joint	MD.07.J00		
Medical Countermeasures for Staphylococcal Enterotoxin B				●		●		Joint	MD.13.J00		
Medical Countermeasures for *Yersinia pestis*				●		●		Joint	MD.14.J00		
Medical Countermeasures for Encephalitis Viruses				●		●		Joint	MD.15.J00		
Multiagent Vaccines for Biological Threat Agents				●		●		Joint	MD.16.J00		
Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases				●		●		Joint	MD.17.J00		
Microelectromechanical Systems	○	○						DARPA	SE.38.01		

● Strong Support ○ Moderate Support



Supporting Technology

L.07	Terrorist Chemical/Biological Countermeasures
CB.02.10	Joint Warning and Reporting Network
CB.06.12	Advanced Lightweight Chemical Protection
CB.07.10	Laser Standoff Chemical Detection Technology
CB.08.12	Advanced Adsorbents for Protection Applications
CB.09.12	Enzymatic Decontamination
CB.16.12	Enhanced Respirator Filtration Technology
CB.19.01	Chemical Imaging Sensor
MD.04.J00	Medical Countermeasures for Botulinum Toxin
MD.05.J00	Chemical Agent Prophylaxes
MD.07.J00	Medical Countermeasures for Vesicant Agents
MD.13.J00	Medical Countermeasures for Staphylococcal Enterotoxin B
MD.14.J00	Medical Countermeasures for *Yersinia Pestis*
MD.15.J00	Medical Countermeasures for Encephalitis Viruses
MD.16.J00	Multiagent Vaccines for Biological Threat Agents
MD.17.J00	Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases
SE.38.01	Microelectromechanical Systems

Figure XII–3. Technology to Capability—Chemical/Biological Warfare Defense and Protection

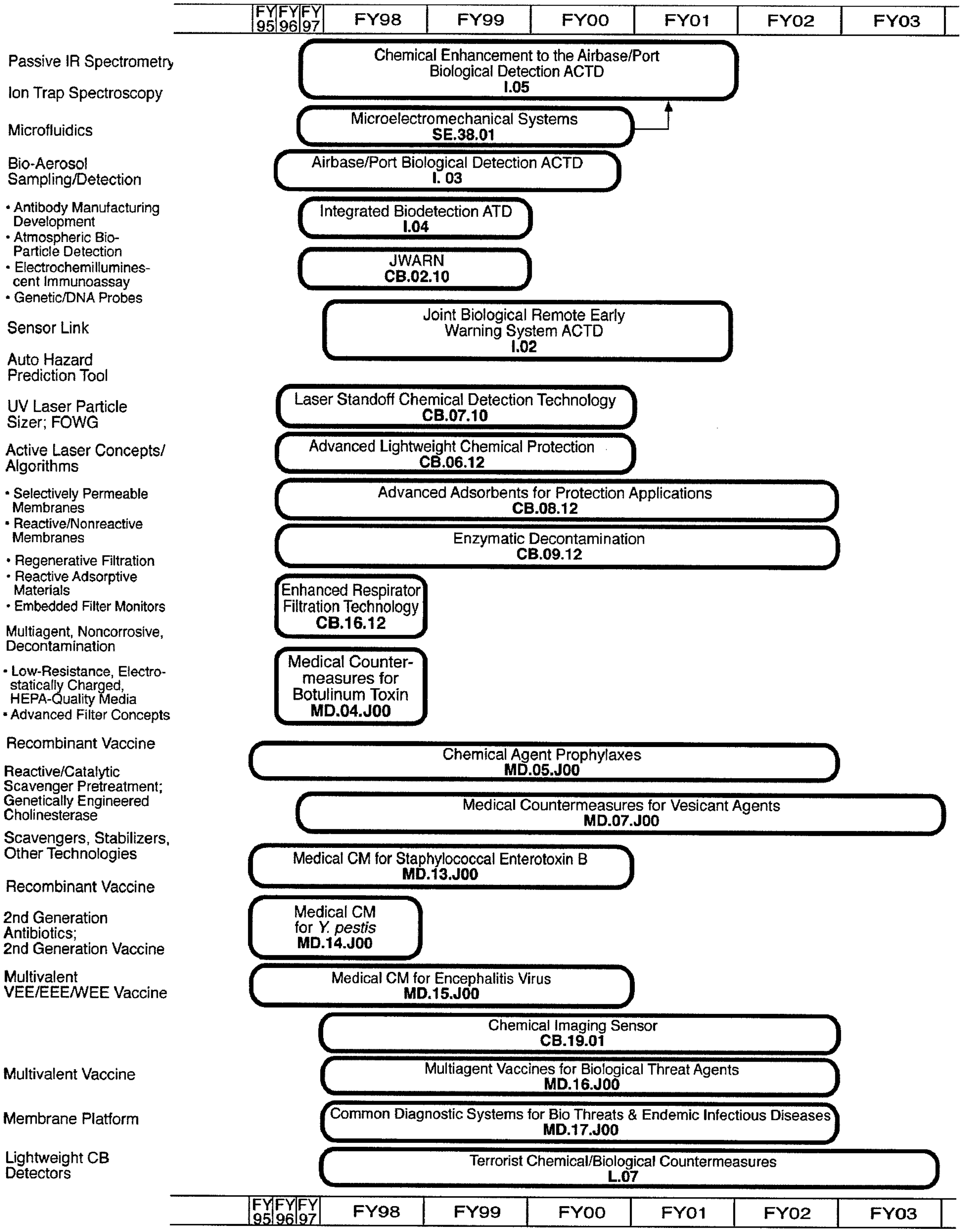


Figure XII–4. Roadmap—Chemical/Biological Warfare Defense and Protection

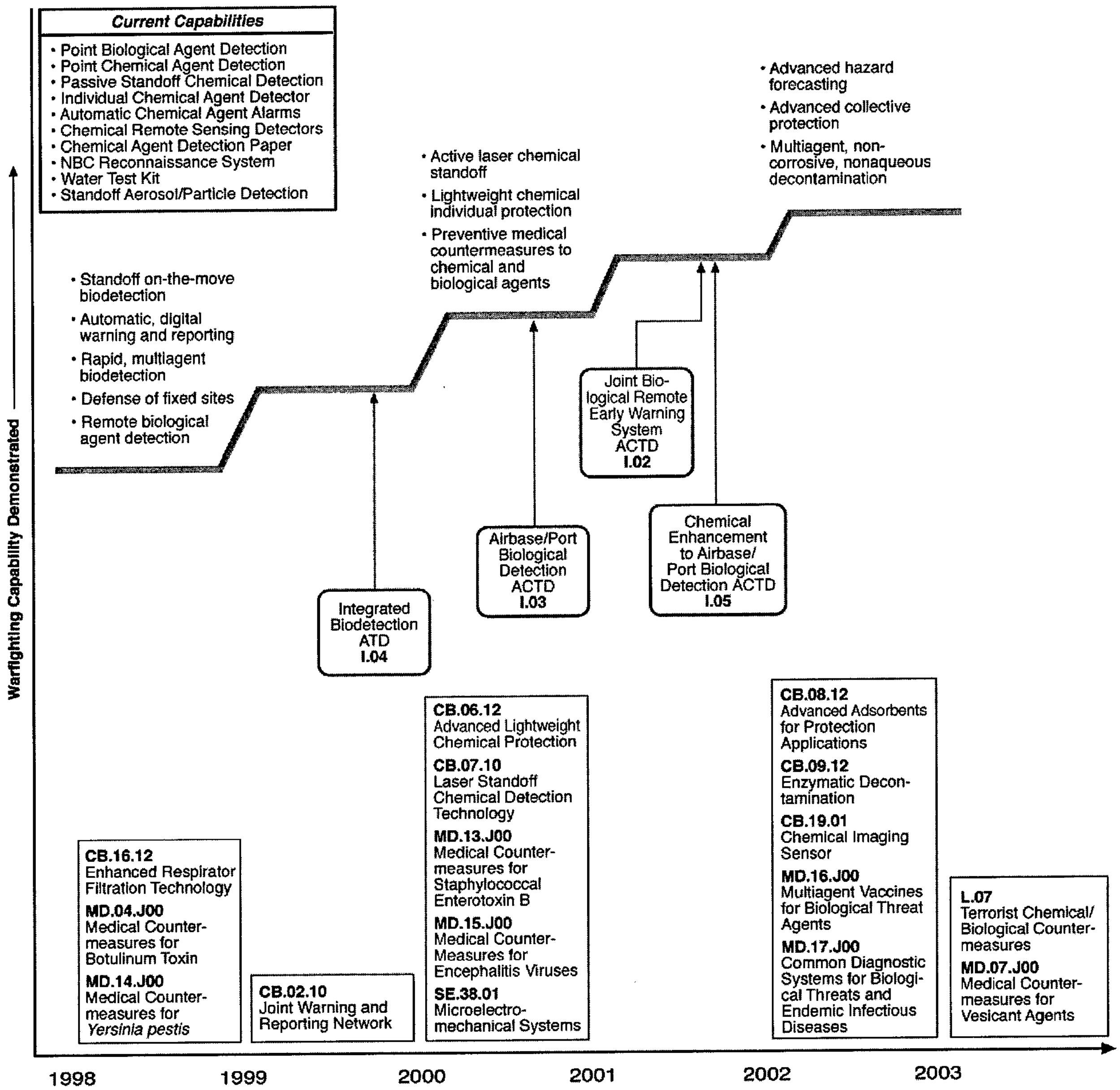


Figure XII–5. Progress—Chemical/Biological Warfare Defense and Protection

2. Counter Weapons of Mass Destruction

The DTOs that are specific to CWMD involve demonstrations to integrate and validate the current state of the art in technology and to identify shortfalls in operational capability that cannot be redressed with existing technologies and products. The fact that these DTOs are demonstrations means that their relationship to other technology development efforts is complex because they relate primarily to past investments.

While the DTOs emphasized in this chapter are directed at important objectives, they are not the only important counterproliferation technology development and demonstration activities. Important requirements are addressed in other programs. Using the set of critical functional

capabilities presented previously, Table XII–8 identifies the contributions that this JWCO's DTOs make to achievement of required capabilities and identifies other activities directed at the same functional capability objectives. These other capabilities are based in large part on the overview provided in the May 1997 report of the Counterproliferation Program Review Committee (CPRC, Reference 23), which provides additional information concerning these activities.

Linkages between DoD S&T activities and required counterproliferation operational capabilities are numerous and complex. For example, significant progress in a number of the programs presented in the Information Superiority and Precision Force JWCO chapters could result in significantly improved capabilities for detection, tracking, and defeat of mobile NBC threats. A subset of the most important linkages between DTAP DTOs and this JWCO are presented in Table XII–9. A brief description of the two WMD DTOs follows:

- *J.03, Counterproliferation I ACTD*, develops, demonstrates, and transitions to the warfighter end-to-end capabilities for defeat of fixed NBC targets with minimized collateral hazards. Target sets include earth-mounded concrete masonry simulated BW storage facilities and a hardened, reinforced concrete facility with burster slab simulating a CW production capability.
- *J.04, Counterproliferation II ACTD*, develops, demonstrates, and transitions to the warfighter improved capabilities for planning, executing, and assessing strikes on WMD-related fixed facilities, including penetration of hardened facilities with standoff weapons.

Table XII–10 presents the demonstrations that support the Counter Weapons of Mass Destruction JWCO. The demonstrations are cross-referenced with the operational capabilities in Figure XII–6, and the relationships among DTOs are plotted in the technology roadmap, Figure XII–7. Figure XII–8 illustrates the expected progress that will be accomplished in this area over the next 3–5 years.

Table XII–8. Contribution of DTOs to Achievement of Required Capability—Counter Weapons of Mass Destruction

Functional Capability Element: Identification and Characterization Sensors

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Weapon-borne sensor provides acceleration history of penetrator to support target characterization and CA.
- Unattended ground sensors characterize and locate critical equipment for targeting and CA.
- Modified tactical forward-looking infrared (TFPM) sensors provide plume signatures for CA.
- UAV-based chemical sensors enable collateral hazards assessment.

Additional DoD Programs

Counterforce Against Mobile Targets

- Critical technology development efforts are presented in the Information Superiority and Precision Force JWCO chapters. Particularly noteworthy is the Surveillance Sensor and Exploitation Systems Program, a DARPA program to develop sensors that can defeat camouflage, concealment, and deception practices. This effort develops foliage-penetrating radar and uses wide-area imagery to provide near-real-time detection of mobile targets.
- Entry Point Screening (L.01) and Automated Terrorist Incidents Indications and Warning (L.10) include radiological/nuclear threats within their scope.

Counterforce Against Fixed Targets

- High-Frequency Active Auroral Research Project (HAARP)—an Air Force and Navy assessment of single-source, long-wavelength electromagnetic waves for detection of underground structures
- Tunnel Defeat Target Demonstration Program—an effort that constructs realistic tunnel facility targets and evaluates capabilities and options for target identification and characterization
- Tactical Multisensor Data Fusion—a program directed at identification and characterization of underground NBC facilities
- Tactical Forward-Looking Infrared (FLIR) Sensor—an effort focusing on modified LANTIRN pod and UAV sensors, and fixed NBC targets
- Tactical UGS (TUGS)—a project with DOE that uses unattended ground sensors for continuous surveillance, characterization, and combat assessment of fixed NBC targets

Proliferation Prevention

- Remote Optical Sensing Program—a program consisting of a demonstration of aircraft-based, long-range LIDAR for remote sensing of NBC weapon production signatures
- Specific emitter identification (SEI) system used by ships to track NBC/M-related shipments
- A DoD/U.S. Customs program to improve foreign customs services' ability to detect and prevent NBC proliferation
- Technical support for controls on Militarily Critical Technology List items
- A joint program with the FBI to enhance the capabilities of foreign law enforcement agencies to stem proliferation at its source
- Treaty verification technology for nuclear test ban, CWC, BWC, other agreements and understandings
- Nuclear Detonation Detection System sensors on GPS satellites
- DoD component support for UNSCOM activities to eliminate NBC weapons and capabilities in Iraq

Functional Capability Element: WMD Target Planning Tools

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Integrated Target Planning Tool Set based on enhanced versions of Integrated Munitions Effectiveness Assessment, Hazard Prediction Assessment Capability, and other products

Additional DoD Programs

- CB.18.01, Integrated Comprehensive Weaponeering Capability, to plan and assess consequences of attacks for a wide range of current weapons and targets
- WE.57.02, Lethality/Vulnerability Models for High-Value Fixed Targets
- DSWA hard-target defeat program to develop and validate a planning tool, Tunnel Munitions Effectiveness Assessment, for defeat of NBC/M and other targets within tunnels or other hardened locations
- IS.12.01, Simulation Representation, to integrate NBC effects models into standard DoD models and simulations

Table XII–8. Contribution of DTOs to Achievement of Required Capability—Counter Weapons of Mass Destruction (continued)

Functional Capability Element: Sensor Data Fusion

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Integrated Target Planning Tool Set for integration and use of all available sensor data relevant to either target planning or collateral hazard forecasting and assessment

Additional DoD Programs

Information Superiority JWCO summarizes DoD S&T directed at sensor data fusion. Particularly noteworthy are:

- Tactical Multisensor Data Fusion—an effort to develop and demonstrate capabilities for integration of weapon-borne sensor and FLIR information to support targeting of underground NBC facilities
- Surveillance Sensor and Exploitation Systems Program—a program to provide near-real-time automated exploitation of wide-area imagery to track critical mobile targets; includes foliage penetrating radar, Semi-Automated Imagery Processing (SAIP) ACTD; demonstrates next-generation automated target recognition
- Information Integration Systems Program—an effort to develop an integrated, all-source, geographically referenced knowledge base for real-time situation assessment and intelligence dissemination
- Enabling technologies presented in the Information Technology and Sensors, Electronics and Battlespace Environments TAP
- Sensor Fusion/Integrated Situation Assessment (H.09)—an effort to develop and demonstrate a combination of offboard, all-source intelligence fusion with onboard sensors for a number of applications, including route planning and retargeting. This may be an important enabling technology for improved counterforce targeting, particularly for mobile NBC targets.

Functional Capability Element: Proliferation Path Analysis

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Demonstration of close-range (e.g., using TUGS) capabilities for characterizing critical nodes within a target facility

Additional DoD Programs

- Much of S&T directed at proliferation path assessment conducted in intelligence community programs that cannot be reported here
- Integrated Proliferation Prevention and Open-Source Monitoring program, including path assessments

Functional Capability Element: Real-Time Weather Data and Forecasts

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Integrated Target Planning Tool Set using advanced weather and wind prediction models to support development of targeting options that minimize collateral hazards

Additional DoD Programs

Counterforce capabilities will benefit from accomplishments in Sensors, Electronics, and Battlespace Environments programs, such as:

- On-Scene Weather Sensing and Prediction Capability (DTO SE.53.01)—an effort to develop improved capabilities for tactical weather forecasting (e.g., to support prediction and monitoring of the transport of collateral hazard aerosols)
- Weather/Atmospheric Impacts on Sensor Systems (DTO SE.52.01)—an effort to develop and validate a modeling capability for assessing the impact of atmospheric conditions on sensor performance

Functional Capability Element: Collateral Effects Prediction and Mitigation

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Demonstration of best possible (given state of the art) automated systems to support collateral hazard prediction and assessment (Hazard Prediction Assessment Capability (HPAC)), using advanced weather and wind prediction models
- Integration of collateral prediction tool with available (within theater) weather data
- UAV-based chemical sensors for collateral effects assessment

Table XII–8. Contribution of DTOs to Achievement of Required Capability—Counter Weapons of Mass Destruction (continued)

Functional Capability Element: Enhanced Penetrating Munition
Defense Technology Objectives
J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Demonstration of Advanced Unitary Penetration to provide factor-of-two improvement over current BLU–109 • Demonstration of counterforce antifacility capability of JASSM • Evaluation of standoff penetration capabilities
Additional DoD Programs
• Multiple options for defeat of hardened targets being evaluated by Hard or Deeply Buried Target Defeat Capability (HDBTDC), an OSD-coordinated effort involving multiple DoD components • Advanced conventional earth-penetrating warheads being developed in support of HDBTDC • Hard-Target Defeat (CB.13.07) • Lethality/Vulnerability Models for High-Value Fixed Targets (WE.57.02)
Functional Capability Element: Enhanced Lethality Warhead
Defense Technology Objectives
J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Demonstration of weaponized enhanced payload to minimize collateral hazards associated with dispersal of NBC materials • Demonstration and evaluation of warheads capable of defeating chemical and biological agents using defeat mechanisms other than high explosives
Additional DoD Programs
• Multiple options for defeat of hardened targets being evaluated by HDBTDC • Advanced conventional earth-penetrating warheads being developed in support of HDBTDC • Hard-Target Defeat (CB.13.07) • Lethality/Vulnerability Models for High-Value Fixed Targets (WE.57.02)
Functional Capability Element: Agent Defeat Payloads
Defense Technology Objectives
J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Demonstration and evaluation of warheads capable of defeating chemical and biological agents using defeat mechanisms other than high explosives
Additional DoD Programs
Delivery by Any Method • Prediction and Mitigation of Collateral Hazards (CB.14.07) • AFRRI research on use of radiation to neutralize agents Delivery by Personnel (e.g., SOF) • Joint Robotics Program (e.g., Remote Ordnance Neutralization System) • Explosive ordnance disposal systems, procedures, sustainment, and low-intensity conflict S&T programs • CW/BW technical support for SOF and first responders • Operational capabilities demonstrated in USMC CBIRF and Army TEU Delivery by Weapon Systems • Air Force/DOE agent defeat weapon program • DDR&E-directed September 1997 review of DoD S&T directed at development of improved agent defeat capabilities

Table XII–8. Contribution of DTOs to Achievement of Required Capability— Counter Weapons of Mass Destruction (continued)

Functional Capability Element: Hard Target Smart Fuzing
Defense Technology Objectives J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Demonstration of Hard-Target Smart Fuze that allows weapon detonation in closer proximity to priority target elements within structures
Additional DoD Programs • Hard or Deeply Buried Target Defeat Capability, including evaluation of advanced fuzing options
Functional Capability Element: All-Weather Guidance and Operations
Defense Technology Objectives J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Inertial Terrain-Aided Guidance System to provide adverse-weather capability while maintaining precision munition level CEPs • Selected weapon system sensor performance in a range of environmental conditions • Ability of sensors to confirm presence of CW/BW agents in a range of environmental conditions
Additional DoD Programs • Weather/Atmospheric Impacts on Sensor Systems (DTO SE.52.01) to develop and validate a modeling capability for assessing the impact of atmospheric conditions on sensor performance • On-Scene Weather Sensing and Prediction Capability (DTO SE.53.01) to develop improved capabilities for tactical weather forecasting (e.g., to support prediction and monitoring of the transport of collateral hazard aerosols)
Functional Capability Element: Combat and Collateral Hazard Assessment
Defense Technology Objectives J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Weapon-borne sensor for combat assessment • Unattended ground sensors for characterization and CA • Modified tactical FLIR to provide plume signatures for CA • Small air vehicle sensor platform with onboard chemical sensor
Additional DoD Programs • Prediction and Mitigation of Collateral Hazards (CB.14.07) • Collaborative DIA/DSWA tunnel target program includes CA
Functional Capability Element: Survivability
Defense Technology Objectives J.03, Counterproliferation I ACTD J.04, Counterproliferation II ACTD • Not included in this demonstration

Table XII–8. Contribution of DTOs to Achievement of Required Capability— Counter Weapons of Mass Destruction (continued)

Additional DoD Programs

Key S&T efforts directed at enhancement of survivability against NBC and other hazards, including:

- Nuclear Hardness and Survivability Testing Technologies (CB.10.07)
- Electronic System Radiation Hardening (CB.12.01)
- Prediction and Mitigation of Collateral Hazards (CB.14.07)
- Balanced Electromagnetic Hardening Technology (CB.15.01)
- Survivability Assessments Technology (CB.17.01)
- Simulation Representation (IS.12.01)
- High-Density, Radiation-Resistant Microelectronics (SE.37.01)

Protection against radiobiological threats is presented in the discussion of AFRRI programs within the Biomedical DTAP. Protection of facilities and forces is addressed in force protection initiatives, balanced survivability assessments, counterterrorism technical support programs, joint physical security equipment efforts, and (outside the S&T program) antiterrorism technical support activities. Relevant S&T is also presented in the Chemical-Biological Defense and Nuclear chapter in the DTAP and in this chapter of the JWSTP. Active defense is presented in the Joint Theater Missile Defense chapter of the JWSTP.

Functional Capability Element: Preventive Defense

Defense Technology Objectives

J.03, Counterproliferation I ACTD

J.04, Counterproliferation II ACTD

- Not included in this demonstration

Additional DoD Programs

- Cooperative threat reduction involving destruction and dismantlement, chain of custody, demilitarization, and other activities to ensure the safety and security of former Soviet weapons of mass destruction
- Technical support for implementation of arms control agreements
- RDT&E directed at ensuring the safety and security of U.S. nuclear systems

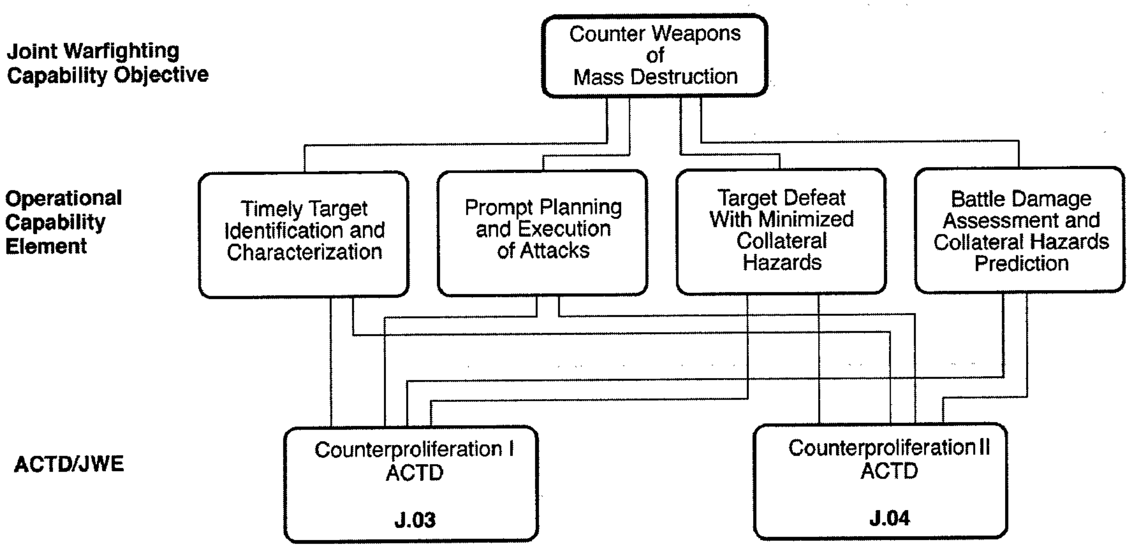
Table XII–9. Defense Technology Objectives— Counter Weapons of Mass Destruction

DTO No.	Title
J.03	Counterproliferation I ACTD
J.04	Counterproliferation II ACTD
CB.02.10	Joint Warning and Reporting Network
CB.10.07	Nuclear Hardness and Survivability Testing Technologies
CB.12.01	Electronic System Radiation Hardening
CB.13.07	Hard-Target Defeat
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.15.01	Balanced Electromagnetic Hardening Technology
CB.17.01	Survivability Assessment Technology
CB.18.01	Integrated Comprehensive Weaponeering Capability
IS.12.01	Simulation Representation
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.52.01	Weather/Atmospheric Impacts on Sensor Systems
SE.53.01	On-Scene Weather Sensing and Prediction Capability
WE.57.02	Lethality/Vulnerability Models for High-Value Fixed Targets

Table XII–10. Demonstration Support—Counter Weapons of Mass Destruction

Demonstration	Operational Capability Elements: Timely Target Identification and Characterization	Prompt Planning and Execution of Attacks	Target Defeat With Minimized Collateral Hazards	Combat and Collateral Hazard Assessment	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD
Counterproliferation I ACTD	●	●	●	●	DSWA	J.03	X	
Counterproliferation II ACTD	●	●	●	●	DSWA	J.04	X	
Joint Warning and Reporting Network	●			●	Army, Marine Corps	CB.02.10		
Nuclear Hardness and Survivability Testing Technologies	○	○	○	○	DSWA	CB.10.07		
Electronic System Radiation Hardening	○	○	○	○	DSWA	CB.12.01		
Hard-Target Defeat		●	●	●	DSWA	CB.13.07		
Prediction and Mitigation of Collateral Hazards	●			●	DSWA	CB.14.07		
Balanced Electromagnetic Hardening Technology	○	○	○	○	DSWA	CB.15.01		
Survivability Assessment Technology	○	○	○	○	DSWA	CB.17.01		
Integrated Comprehensive Weaponeering Capability		●			DSWA	CB.18.01		
Simulation Representation	○	○	○	○	DSWA, DMSO	IS.12.01		
High-Density, Radiation-Resistant Microelectronics	○	○	○	○	Air Force	SE.37.01		
Weather/Atmospheric Impacts on Sensor Systems	●	●		●	Air Force, Army, Navy	SE.52.01		
On-Scene Weather Sensing and Prediction Capability	●	●		●	Navy, Air Force, Army	SE.53.01		
Lethality/Vulnerability Models for High-Value Fixed Targets	○	●		○	DSWA, Air Force	WE.57.02		

● Strong Support ○ Moderate Support



Supporting DTAP DTOs*

CB.02.10	Joint Warning and Reporting Network
CB.10.07	Nuclear Hardness and Survivability Testing Technologies
CB.12.01	Electronic System Radiation Hardening
CB.13.07	Hard-Target Defeat
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.15.01	Balanced Electromagnetic Hardening Technology
CB.17.01	Survivability Assessment Technology
CB.18.01	Integrated Comprehensive Weaponeering Capability
IS.12.01	Simulation Representation
SE.37.01	High-Density, Radiation-Resistant Microelectronics
SE.52.01	Weather/Atmospheric Impacts on Sensor Systems
SE.53.01	On-Scene Weather Sensing and Prediction Capability
WE.57.02	Lethality/Vulnerability Models for High-Value Fixed Targets

*Significant enhancements to counterforce capabilities may also result from progress in other JWCOs, notably Information Superiority (improved capabilities for detection of mobile NBC targets for characterization and status information for fixed targets), Chemical/Biological Warfare Defense and Protection (prediction and mitigation of collateral hazards and passive defense), and Combating Terrorism (force prediction against terrorist/paramilitary NBC threats). Research directed at additional facets of the DoD counterproliferation mission is presented in other JWCOs: Information Superiority (strategic and tactical intelligence, battlefield surveillance), Joint Theater Missile Defense (active defense), Chemical/Biological Warfare Defense and Protection (passive defense), Combating Terrorism (countering paramilitary, covert delivery, and terrorist NBC threats).

Figure XII–6. Technology to Capability—Counter Weapons of Mass Destruction

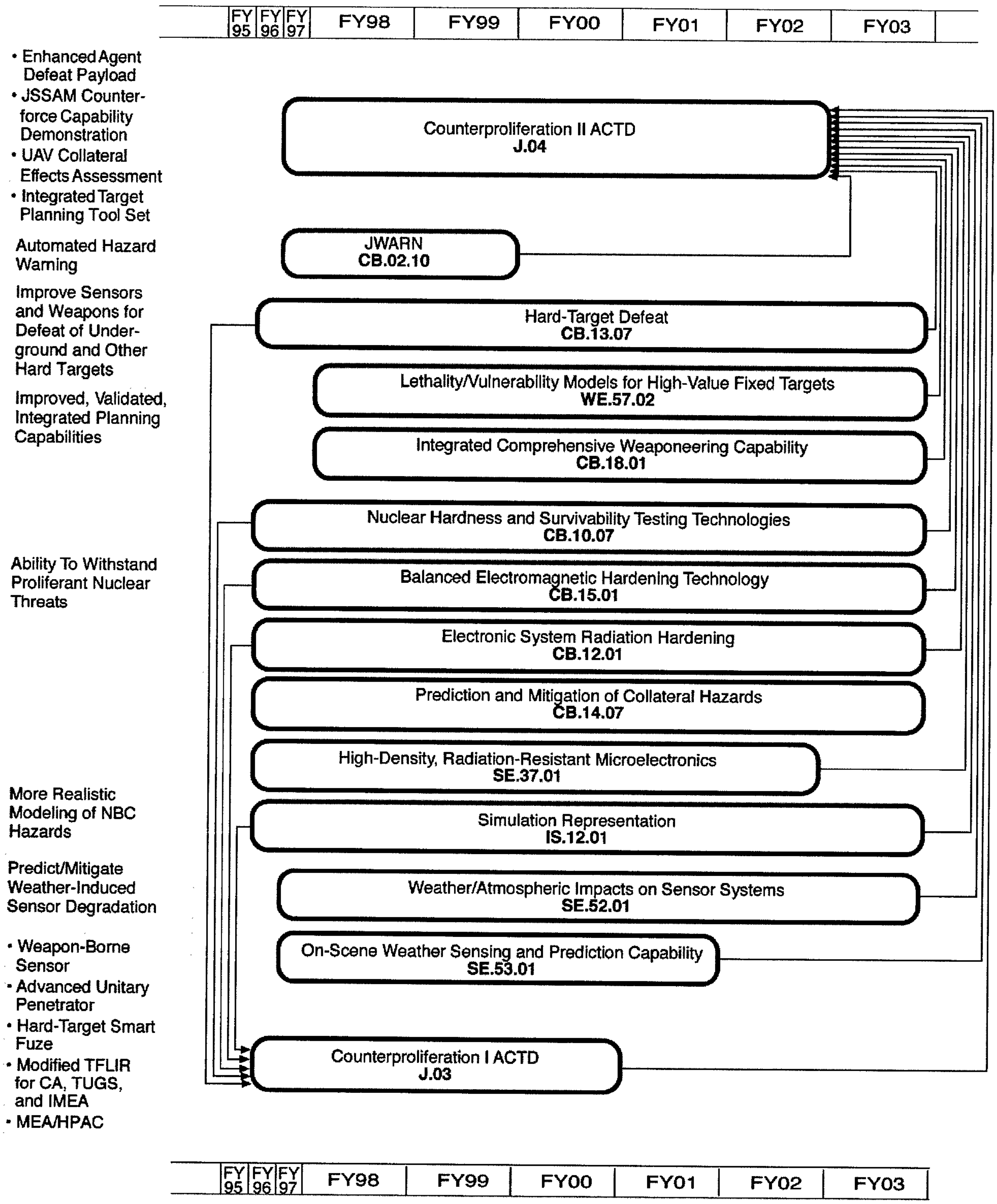


Figure XII–7. Roadmap—Counter Weapons of Mass Destruction

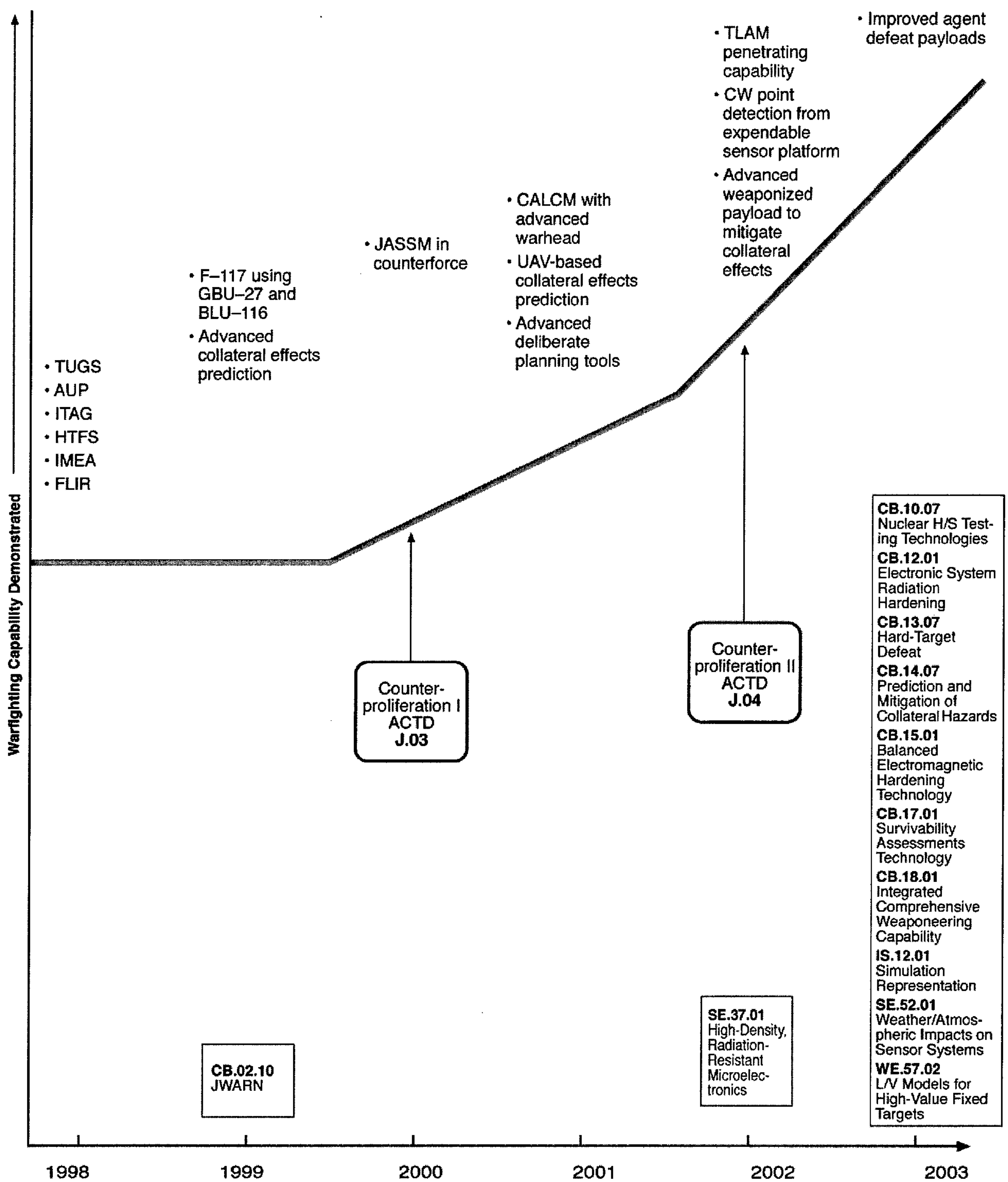


Figure XII–8. Progress—Counter Weapons of Mass Destruction

F. SUMMARY

1. Chemical/Biological Warfare Defense and Protection

Science and technology efforts in CB warfare defense provide the basis for significant future advances in protecting U.S. forces from the CB threat and address the highest priority of this JWCO. Warning and reporting is key to detection efforts because it integrates detection systems into the digital battlefield and provides commanders with information to accurately visualize the battlefield and assess warfighting options. Achieving these objectives will ensure that the warfighter is equipped with state-of-the-art capabilities and will not face the same deficiencies encountered during Operation Desert Storm.

2. Counter Weapons of Mass Destruction

The DTOs within the Counter Weapons of Mass Destruction JWCO demonstrate improvements in capability that respond to shortfalls that were identified during the Gulf War and provide part of the technical basis needed for redressing remaining shortfalls in operational capabilities. Proliferation prevention is necessarily the first priority. Since prevention has already failed in some parts of the world and may not be successful in the future, additional enhancements in capability are needed. The priorities are to develop and deploy weapons that can effectively defeat NBC targets with minimized collateral hazards. Achieving these objectives will ensure that the warfighter is equipped with state-of-the-art capabilities and will not face the same deficiencies encountered during Operation Desert Storm.

3. Strategic Context for Planning and Program Development

In the post–cold war strategic environment, there are three scenarios in which there might be WMD threats to the United States and its interests:

Major Confrontation With a Potential Nuclear Peer Adversary. Such a confrontation might occur in the context of a major theater war or might involve a confrontation with a WMD-armed major power adversary as during the cold war. This class of contingencies is addressed by the QDR force structure and current DoD/DOE infrastructure.

DoD S&T programs directed at these requirements are presented within the Sustainment of Strategic Systems JWCO. Some of the programs directed at Sustainment of Strategic Systems also have direct relevance for the Counter Weapons of Mass Destruction JWCO. For example, survivability programs develop capabilities needed during potential confrontations with nuclear-capable peer adversaries and, in counterproliferation contingencies, reduce incentives for proliferation and provide protection against WMD use.

Unconventional or Terrorist WMD Threats. The salience of these threats is no longer hypothetical. Terrorist use of nerve gas killed 12 and injured 5,500 people in the March 1995 incident on the Tokyo subway. In November 1995, a Chechyen insurgent leader directed a Russian news agency to a park in Moscow where a radiological weapon was found. To provide improved focus for DoD S&T efforts directed at such threats, a Combating Terrorism JWCO has been established.

Regional Contingencies Involving WMD-Capable Antagonists. Proliferation potential is broadly distributed. Many potential antagonists could develop nuclear, radiological, chemical, or biological weapons, given a decision to do so by national leaderships.

Asymmetric Threats

"...the United States must plan and prepare to fight and win under conditions where an adversary may use asymmetric means against us—unconventional approaches that avoid or undermine our strengths while exploiting our vulnerabilities. Because of our dominance in the conventional military arena, adversaries who challenge the United States are likely to do so using asymmetric means, such as WMD, information operations, or terrorism." (Reference 24, p. 12)

The *Concept for Future Joint Operations* (Reference 20), published by the Joint Chiefs of Staff, presents a number of potential "asymmetric counters" developed in a Defense Science Board assessment—military capabilities that adversaries may develop and deploy to offset the United States' conventional superiority. Of particular importance are the potential asymmetric counters that are likely to be relatively more effective against the United States and relatively easier for adversaries to develop, deploy, and employ. The S&T activities in this chapter are directed at asymmetric counters involving WMD threats.

A spectrum of military objectives and required military capabilities is shown in Table XII–11.

Table XII–11. Military Objectives and Capabilities During Major Theater War Scenarios Involving NBC-Capable Antagonists

Military Objective	Required Military Capabilities
Prevent Use of WMD • Deter and Reduce Incentives for Use • Destroy Prior to Use	Survivability against NBC weapons reduces incentives for acquisition or use of WMD by reducing the military value of such actions. If forces do not have requisite levels of survivability, perverse incentives for use of NBC weapons as asymmetric offsets may result. Counterforce capabilities that provide lethality options with minimized collateral effects contribute to deterrence and provide capabilities for destroying NBC weapons and facilities.
If WMD Are Used, Protect Against and Limit Damage	This objective requires active defense for defeat of threat weapons and passive defense/survivability capabilities.
If WMD Are Used, Proceed to Decisive War Termination	Counterforce capabilities are critical, particularly the military capabilities required to deny sanctuaries (targets that cannot be defeated with current weapons).

Defense Department Counterproliferation Objectives and Programs. "To minimize the impact of proliferation on American interests, it is the policy of the United States not only to prevent and deter NBC use, but also to operate and counterstrike successfully when faced with NBC threats or use" (Reference 25, p. 84). As outlined in the most recent report from the Counterproliferation Program Review Committee, critical support for achievement of required DoD counterproliferation capabilities is provided in programs accomplished within the Department of Energy and the intelligence community.

Military Capabilities Needed for Counterproliferation. It is the Defense Department's policy "to integrate proliferation concerns into the existing DoD planning process" (Reference 26, p. 48). The same integration is evident in DoD S&T programs; many of the critical military capabilities required for counterproliferation are accomplished in activities that are responsive to a range of military requirements. The same set of core research and development activities supports activities directed at all of the current NBC threats. This work is presented in the Chemical/Biological Defense and Nuclear chapter within the *Defense Technology Area Plan.*

The annual executive branch report to Congress on counterproliferation programs (Reference 23) identifies seven key functional areas. Each of these areas corresponds to one or more chapters within this edition of the JWSTP (Table XII–12).

Table XII–12. Correspondences Between Joint Warfighting Capability Objectives and Counterproliferation Functional Areas

Key Counterproliferation Functional Areas (Reference 23, p. 1–5)	Corresponding Chapters of JWSTP
Proliferation Prevention	Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction
Strategic and Tactical Intelligence	Information Superiority
Battlefield Surveillance	Information Superiority
Counterforce	Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction Information Superiority and Precision Force (particularly for defeat of mobile WMD targets)
Active Defense	Joint Theater Missile Defense
Passive Defense	Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction
Countering Paramilitary, Covert Delivery, and Terrorist NBC Threats	Combating Terrorism Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction

In the interest of avoiding redundancy, only brief cross-citations are made to efforts directed at developing military capabilities needed for aspects of counterproliferation operations that are addressed in other JWSTP chapters. This chapter emphasizes efforts relevant to counterforce, proliferation prevention, and chemical and biological defense. It merits note that survivability against NBC and conventional threats is required for accomplishment of DoD counterproliferation missions.

CHAPTER XIII

COMBATING TERRORISM

CHAPTER XIII
COMBATING TERRORISM

A. DEFINITION

Combating Terrorism (CbT) is the capability to oppose terrorism throughout the threat spectrum, including antiterrorism (i.e., defensive measures to reduce vulnerability) and counterterrorism (i.e., offensive measures to prevent, deter, and respond).[1] This capability includes personnel protection, assault, explosive detection and disposal, blast mitigation, investigative science and forensics, physical security and infrastructure protection, surveillance, and collection; and enhanced support to allied land, sea, air, and riverine forces in the form of improved detection, monitoring and tracking, intelligence and logistics communications, training, and planning. The principal goal of CbT is to protect lives and resources and allow U.S. forces the freedom of action required to accomplish assigned missions. It provides a critical link to the lower tier of the multilayered Full Dimensional Protection operational concepts outlined in *Joint Vision 2010,* issued by the Chairman of the Joint Chiefs of Staff.

Force protection is the security program designed to protect military personnel, civilian employees, family members, facilities, and equipment, in all locations and situations. Force protection is accomplished through the planned and integrated application of combating terrorism, physical security, operations security, and personal protective services, and is supported by intelligence, counterintelligence, and other security measures.

In 1986, President Reagan commissioned a task force on combating terrorism. This task force found the U.S. response capability was hampered by the inadequate research and development structure that supported it. In response to the task force findings, the National Security Council (NSC) established what ultimately became the Interagency Working Group on Counterterrorism (IWG/CT). In 1987, the Technical Support Working Group (TSWG) was created as a sub working group of the IWG/CT, with the mission to conduct fast-track (1–3 years) R&D and prototyping of technologies to combat terrorism. In the longer term (5–10 years), the CbT S&T plan leverages applied research (6.2) investments in numerous DTAP DTOs and basic research (6.1) investments in many different scientific disciplines, as discussed in the *Basic Research Plan* (Reference 2).

The TSWG operates through the Department of State Office of the Coordinator for Counterterrorism and the Department of Defense Office of the Assistant Secretary for Special Operations/ Low-Intensity Conflict (SO/LIC). DoD provides the majority of program funding via the Counter Terror Technical Support Program, as well as program oversight and support from the Under Secretary of Defense for Acquisition and Technology, through the Office of the Director, Defense Research and Engineering. The TSWG maximizes multiagency participation (from eight

[1] Joint Publication 1–02, *Department of Defense Dictionary of Military and Associated Terms* (Reference 11, available on the Internet at http://www.dtic.mil/doctrine/jel/dodict/), provides the following definitions: *Terrorism* is the calculated use of violence or threat of violence to inculcate fear and to coerce or intimidate governments or societies in the pursuit of goals that are generally political, religious, or ideological. *Antiterrorism* actions are defensive measures that reduce the vulnerability of individuals and property to terrorist acts. Such measures include limited response and containment by local military forces. *Counterterrorism* actions are offensive measures taken to prevent, deter, and respond to terrorist acts.

departments and over 50 federal agencies) to identify requirements for joint users. By direction of Congress, the TSWG also promotes cooperative counterterrorism R&D with allies and has bilateral agreements with Israel, the United Kingdom, and Canada. TSWG focus areas for CbT include explosives detection, weapons of mass destruction (WMD) countermeasures, advanced surveillance technologies, small-unit capabilities, ballistic protection technologies, and information warfare. The TSWG has operationally deployed or completed the transition of over 70 percent of its tasks since its inception. Based on this record of success, the CbT JWCO plan builds on the TSWG requirements base and associated R&D structure. Future updates of the plan will include more explicit linkages to the Joint Warfighters' Mission Area Analysis.

In September 1996, the Secretary of Defense included CbT as a major mission consideration of DoD and convened the 1997 Defense Science Board summer study on the *DoD Response to Transnational Threats* (Reference 27). This study resulted in several recommendations that are currently being implemented. In addition, the Chairman of the Joint Chiefs of Staff embraced and implemented recommendations presented in the Secretary of Defense Task Force Report (Reference 28) on how to prevent or minimize the consequences of future terrorist attacks. Due to the high priority accorded CbT by the President, the Secretary of Defense, and numerous departments and federal agencies, and the collaborative efforts of the Joint Staff, DDR&E, and all the services, this new and important Joint Warfighting Capability Objective has been established for inclusion in this edition of the *Joint Warfighting Science and Technology Plan.*

B. OPERATIONAL CAPABILITY ELEMENTS

CbT is a matter of high priority for the United States. Although the number of incidents of international terrorism has decreased over the last decade, the number of deaths associated with such incidents has increased in recent years. The overall threat to U.S. military and civilian personnel posed by terrorists remains a serious concern. The terrorist attack on the Khobar Towers U.S. military housing facility in Saudi Arabia in June 1996, which claimed the lives of 19 U.S. citizens and caused injuries to hundreds of others, serves as a recent and harsh reminder of how devastating such incidents can be. Terrorist acts against both military and civilian targets in the Middle East continue to occur on a regular basis. Earlier attacks in New York and Oklahoma City (with 168 lives lost, an extreme example of domestic terrorism), however, have revealed the true global nature of the problem: Significant vulnerabilities to terrorist acts exist even within the United States. Comprehensive ongoing efforts to develop critical new capabilities for mitigating the threat and enhancing the ability of our military forces—as well as civilian law enforcement agencies and emergency response teams—to respond to terrorist actions must be intensified.

Key required operational capabilities for combating terrorism can be incorporated into three principal categories: prevention, protection, and response. They reflect distinctly different facets of the problem, and each offers its own set of challenges and opportunities. Figure XIII–1 illustrates a notional concept for combating terrorism based on achieving advanced capabilities in each of these areas. Within these categories, 11 specific operational capability elements important to combating terrorism on many different fronts have been identified. The principal categories and specific operational capability elements within each category are briefly discussed below.

Prevention. The safety and security of U.S. military and civilian personnel potentially subject to terrorist attacks can be enhanced most effectively by developing new capabilities pertinent

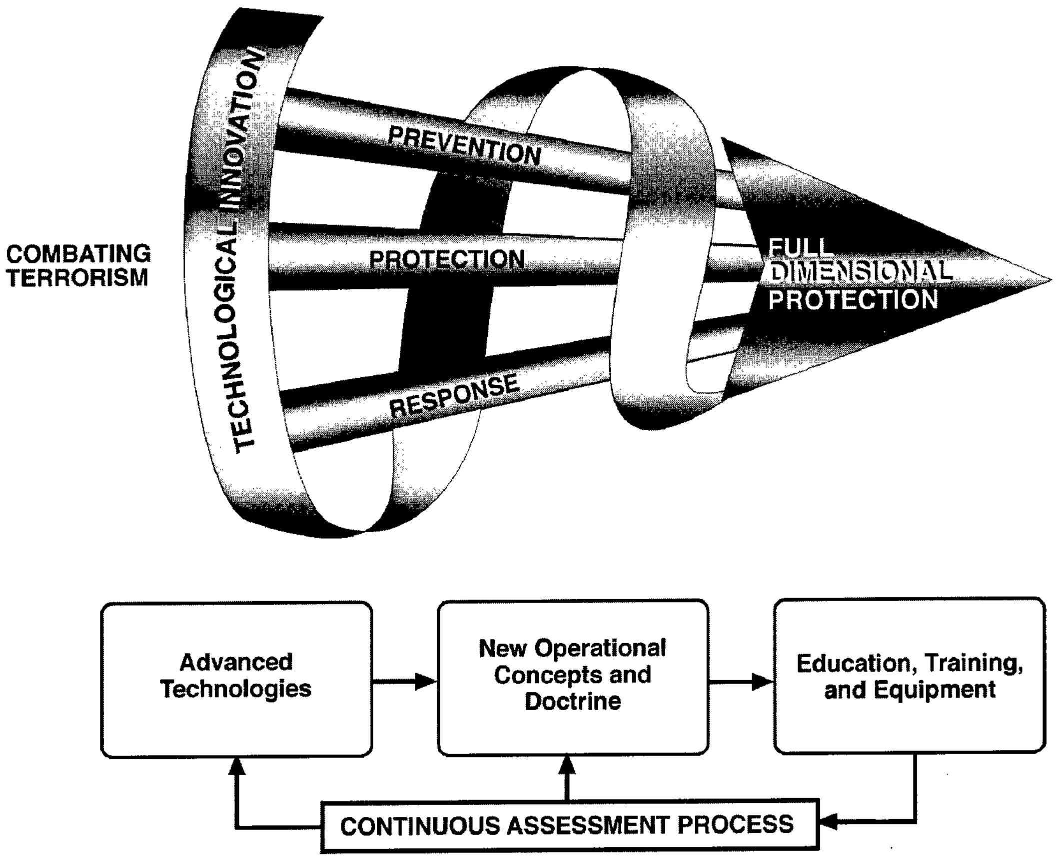


Figure XIII–1. Concept—Combating Terrorism

to preventing their occurrence. More effective prevention requires the development of new or improved capabilities for identifying terrorist organizations and monitoring their activities, identifying and tracking individual terrorists, detecting a wide range of potential threat agents and explosive devices, limiting access to areas of significant potential vulnerability, and, when necessary, conducting decisive preemptive strikes. All of these operational capabilities are strongly interrelated.

- *Indications and Warning.* Improved terrorist identification, surveillance, and tracking capabilities are needed to help prevent terrorist acts by facilitating the timely interdiction of terrorists and threat agents and devices; early warning of impending attack will also enable the implementation of protective countermeasures. The development of improved capabilities for detecting threat agents and devices at extended standoff distances will strengthen perimeter security and increase warning time, again facilitating countermeasure actions. Such actions will also be enhanced by the development of personnel alerting systems.

- *Deterrence.* Improved capabilities for detecting terrorists and threat agents and devices must be developed to enable more effective entry-point screening and improved perimeter security, thereby helping to deter certain types of attacks by terrorists. Terrorist awareness of significant U.S. preemptive strike or retaliation capabilities can also be expected to provide deterrence benefits.

- *Denial.* Denying access to potential targets is a critical aspect of preventing terrorist attacks. Advanced capabilities for identifying and tracking terrorists, for detecting terrorists hidden in vehicles, and for detecting concealed threat agents and devices (both at short ranges and at extended standoff distances) are needed to help ensure that denial objectives can be met.

- *Preemptive Strike.* Under some circumstances, where the potential consequences of anticipated terrorist attacks are great, the execution of rapid and precise preemptive strike operations may offer the only assured means for preventing their occurrence. Such operations require advanced surveillance and tracking capabilities critical to targeting, as well as the availability of a variety of tactical operations support equipment, including advanced weapons, information and communications systems, and specialized protective measures for individual combatants.

Protection. Although improved capabilities for preventing terrorist actions will help to reduce the overall threat, preventing all such incidents is a daunting challenge not likely to be overcome. Advanced supplemental protective capabilities for combating terrorism that help to limit the effectiveness and mitigate the consequences of terrorist attacks on facilities, elements of the defense infrastructure, and personnel are needed.

- *Facilities.* New building design features and the development of protective barriers for mitigating the effects of explosive blasts are needed to reduce the consequences of terrorist attacks on a variety of military and other government facilities. Effective means for upgrading existing structures must also be developed. The development of improved capabilities for entry-point screening of personnel, automobiles, and cargo vehicles to identify known or potential terrorists and to detect the presence of dangerous material—particularly commercial, military, or improvised explosives (already recognized as preventive measures)—will also contribute to the protection of facilities.

- *Infrastructure.* Protecting critical elements of the defense infrastructure—including communications networks, transportation systems, electric power grids, natural gas and petroleum distribution systems, and food and water supply systems—requires development of significant new capabilities for recognizing potential vulnerabilities, understanding their consequences, and developing robust protective countermeasures and stability and support operations. Maintaining the continued availability of many of these infrastructure elements is of critical importance to the planning and execution of U.S. military operations.

- *Personnel.* The protection of military and civilian personnel against terrorist attacks will be enhanced through improved deterrence and denial capabilities, as well as through advanced building design features and structural blast mitigation systems. Advanced body armor and improved chemical/biological (CB) agent protection systems will help to reduce casualties associated with terrorist incidents. Improved capabilities for detecting, neutralizing, and limiting the dissemination of chemical and biological agents are also needed to enhance personnel protection.

Response. A comprehensive range of capabilities are required for responding to terrorist attacks. These capabilities address recognized needs pertinent to crisis management, effective and expeditious handling of the consequences of various types of attack, identifying the perpetrators of terrorist actions, and planning and executing appropriate retaliatory operations.

- *Crisis Management.* The development of improved capabilities for detecting, diagnosing, and disabling terrorist threat devices, particularly small improvised explosive devices (IEDs) and large vehicle bombs, will help to reduce the severity of many attacks. Improved procedures for countering the release and dissemination of chemical and biological threat agents, and new capabilities for conducting counterterrorist operations, are also needed to improve the ability to manage crises arising from terrorist actions.

- *Consequence Management.* New capabilities for rapidly and effectively handling mass casualties, including injuries caused by explosives or associated with the release of chemical and biological agents, must be developed. Significant advances in the development of effective countermeasures for neutralizing the effects of such agents and limiting their dissemination are likewise critical to reducing the consequences of terrorist acts. Improved measures for responding to attacks on elements of the defense infrastructure that will minimize their impact and enable rapid restoration of compromised services are also needed.

- *Attribution.* The development of improved capabilities for rapidly and reliably identifying the perpetrators of terrorist incidents will enable the planning and execution of appropriate retaliatory operations, as well as the implementation of effective countermeasures to possible additional attacks. Improved forensics capabilities will also support criminal prosecution efforts by the Department of Justice.

- *Retaliation.* The ability to execute a variety of military operations in retaliation for terrorist attacks is important to ensuring that no terrorist act go unpunished and will contribute to the deterrence of future incidents. New capabilities for conducting such operations with greater speed, precision, and a higher level of assured effectiveness are needed to reduce casualties suffered by U.S. forces and minimize fratricide problems, particularly in hostage situations.

Significant advances in all of the areas covered by these operational capability elements will greatly enhance the ability of U.S. military forces to combat terrorist actions wherever they might occur. Law enforcement agencies will also benefit from these advances through cooperative efforts involving technology transfer.

C. FUNCTIONAL CAPABILITIES

To achieve the warfighter objectives represented by the Operational Capability Elements (OCEs) described above, numerous specific functional capabilities are required. These functional capabilities are listed in Table XIII–1, which illustrates their relationship to the individual OCEs. Most of the specified functional capabilities show a strong correlation with many different OCEs. Accelerated technology developments supporting each of the identified functional capabilities will greatly enhance the effectiveness of U.S. forces engaged in CbT operations.

Table XIII–1. Functional Capabilities Needed—Combating Terrorism

	Operational Capability Elements											Mission Area Analysis Objectives			
	Prevention				Protection			Response							
Functional Capabilities	Indications and Warning	Deterrence	Denial	Preemptive Strike	Facilities	Infrastructure	Personnel	Crisis Management	Consequence Management	Attribution	Retaliation	Deter Incidents	Employ Countermeasures	Mitigate Effects	Incident Recovery
1. Threat Device Detection		●	●		○	○	○	●				X			
2. Terrorist Surveillance and Tracking	●	○	●	●						●	●	X			
3. Situational Awareness	●	●	○		○	○	●	●	○			X	X	X	X
4. Precision Insertion and Targeting		○	○	●							●	X			
5. Simulation and Training		●	●	●	●	●	●	●	●		●	X	X	X	X
6. Threat Warning Dissemination	●		●		○	○	○	●				X	X		
7. Chemical/Biological Agent Protection					●	●	●	●	○				X		
8. Threat and Vulnerability Assessment			●		●	●	●					X	X		
9. Protective Materials and Structures		○			●	●	●	○					X	X	
10. Remote Operations			●		○	○	●		●			X	X	X	
11. Threat Device Disablement			●		○	○	○	●					X		
12. Incident Analysis	●	○			○	○	○	●	●	○	○			X	
13. Nonlethal Options		●			●	●	○		●			X	X		
14. Mitigation/Decontamination of Chemical/Biological Agents					○	○	●	●	●				X	X	
15. Mass Casualty Medical Care							●		●					X	
16. Asymmetric Threat Containment	○	○			○	●	○	●	●				X	X	
17. Rapid Response			○		○	○	○	●	●	●	●		X	X	X
18. Military/Law Enforcement Agency Coordination	○	○						●	●	●	●			X	X
19. Forensic Analysis										●					X
20. Post-Incident Recovery		○	○		○	○	○	●	●	○	○			X	X
21. Dynamic Threat and Vulnerability Analysis	●	●	○		●	●	●	●	●			X	X	X	X

● Strong Support ○ Moderate Support X MAA linkage

Table XIII–1 also correlates the required functional capabilities with the four key objectives specified in the 1997 Warfighters' Mission Area Analysis (MAA):

- *Deter Incidents:* Develop innovative new technologies and use emerging detection and information-sharing technologies to provide for the functional capability to conduct actions that dissuade an adversary from all aspects of a contemplated terrorist action.

- *Employ Countermeasures:* Evolve developed technological solutions and provide improvements on legacy systems to facilitate the functional capability to employ activities, devices, or techniques to impair the operational effectiveness of the terrorist activity.

- *Mitigate Effects:* Integrate emerging technological advances with innovative thinking to provide new warfighting functional capabilities for conducting actions able to lessen the impact of terrorist events.

- *Incident Recovery:* Incorporate and exploit advanced technologies to provide functional capabilities that facilitate post-incident continuation of military missions and enhance antiterrorist operations.

The MAA serves both as an important fundamental guide for S&T program planners and as a basis for Joint Warfighting Capability Assessments for the Chairman's semiannual program assessment. This assessment supports preparation of the DoD budget.

D. CURRENT CAPABILITIES, DEFICIENCIES, AND BARRIERS

The operational capabilities required to effectively combat terrorism comprise a complex mixture of actions spanning the entire warfighting spectrum. Although the capabilities required for CbT are similar in many respects to those required for conducting Military Operations in Urban Terrain (MOUT), the unpredictable nature and the political implications of successful terrorist actions present many additional and unique challenges to our warfighting personnel. Capabilities that help to ensure the protection of our forces are clearly of paramount importance, but we must also be prepared to deal with the consequences of terrorist actions while simultaneously and continuously acting to prevent their occurrence in the first place. Table XIII–2 identifies many recognized limitations and potential technology solutions for each of the main operational capability elements.

Current capabilities for *preventing* terrorist incidents derive principally from intelligence sources that provide advance warning or entry-point screening methods that enable the interdiction of threat devices at security checkpoints. Unfortunately, the wide range of terrorist threats and potential actions render these capabilities of limited effectiveness. An additional challenge to terrorist incident prevention is the fact that many attacks are perpetrated by very small groups that are difficult to identify and infiltrate. In these cases, very little or no advance warning can be expected. For this reason, effective screening methods are of utmost importance. At present, the best available screening methods are use of canines or time-intensive manual searches. These methods are incapable of detecting the full spectrum of threats. These threats include explosives; guns; chemical, biological, and radiological agents; as well as attacks on information and communications systems, or other critical elements of the defense infrastructure.

Table XIII–2. Goals, Limitations, and Technologies—Combating Terrorism

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Prevention			
Prevent terrorist attacks on U.S. military forces, civilians, and installations.	Threat detection	High false alarms Range Resolution Size and portability of equipment Automated explosives detection capabilities nonexistent Ability to distinguish explosives from background Few viable explosive detectors Intrusive inspection techniques Low throughput Size and portability of equipment Operator safety	Gamma imaging Mass and ion-mobility spectrometry Transverse field compensated IMS Surface acoustic wave devices Chemiluminescence X-ray imaging Canines UV fluorescence Fiber optic wave guides Handheld assayers DNA amplification Miniature flow cytometer Remote explosives detection Neutron technologies Multisensor fusion Ultrasonic inspection techniques High-repetition-rate laser imaging systems Multisensor automated target recognition Secure firewalls and guards Trusted systems
	Terrorist surveillance and tracking	Blooming on night vision goggles Size and portability of equipment	Audio/video surveillance End-spoiled microchannel plates Ion-barrier removal
	Situation awareness	Multiple data formats Lack of measures of effectiveness Data availability	Expert systems High-bandwidth datalinks
	Precision insertion and targeting	Reliable targeting Weapon accuracy	Miniature laser rangefinders Miniature ballistic computers Advanced focal plane arrays Precision non-GPS navigation Low-cost robotic platforms Non-line-of-sight (NLOS) weapons
	Simulation and training	Required training Complexity of analytical tools Interoperability	Expert systems Latent semantic indexing Fuzzy logic Genetic algorithms Neural nets Automated planning tools
	Threat warning dissemination	Minimal real-time intelligence to warfighter	High-bandwidth datalinks Database mining Assessment tools

Table XIII-2. Goals, Limitations, and Technologies—Combating Terrorism (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Protection			
Protect U.S. forces and facilities at all levels from attacks while maintaining freedom of action during deployment, maneuver, and engagement	Chemical/biological agent protection	Size and portability of equipment Existence of CB prophylaxis Onsite CB agent characterization No single protective mask meeting requirements Cost of protective garb	Vaccine development Drug prophylaxis against chemical agents Personal dosimeter Direct gene identification Upconverting phosphors Reactive and nonreactive lightweight materials and membranes for protection against all identified and possibly improvised CB agents Reactive-adsorptive materials
	Threat and vulnerability assessment	Modeling of explosive effects No adequate means to ensure protective factors in field No single material providing full-spectrum protection	Modeling, simulation, and assessment tools Real-time, all-source data fusion
	Protective materials and structures	Nonideal explosive modeling capability Understanding of infrastructure interdependencies Lifetime of equipment Cost-effective structured retrofit methods	Advanced materials Advanced construction methods Lightweight ballistic protective materials PBO fibers Mylar films and adhesives for window protection Carbon fiber wraps for structural hardening
	Remote operations	Inadequate effectiveness of tool delivery systems	Robotics Remote IED initiation countermeasures
	Simulation and training	Required training Complexity of analytical tools Interoperability	Expert systems Latent semantic indexing Fuzzy logic Genetic algorithms Neural nets Automated planning tools
Operational Capability Element: Response			
Provide a rapid and coordinated set of actions that minimize the effects of a terrorist incident and maintain the capability of U.S. forces to execute national security policy	Threat device disablement	Onsite analysis tools Operator safety Large-device disruption capabilities Nonintrusive diagnostic capabilities for threat devices Cost, weight, and power for individual equipment	Water disruption techniques Dynamic entry techniques Robotics Kinetic energy neutralization and chemical neutralization Enhanced explosive materials

Table XIII–2. Goals, Limitations, and Technologies—Combating Terrorism (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Response (continued)			
	Incident analysis	Possibility of secondary devices Range Sensitivity Resolution Onsite chem/bio agent characterization Size and portability of equipment	X-ray imaging Gamma-ray imaging Neutron analysis
	Nonlethal options	Environmental impact No tunable (selectable effects) munitions	Chemical foams HPM Acoustic devices Motion inhibitors Chemical markers
	Mitigation/decontamination of CB agents	Logistical support for decontamination	Hot gas decontamination UV flashlamp decontamination Portable decontamination equipment
	Mass casualty medical care	Response time Existence of chem/bio prophylaxis Location of casualties Treatment modalities with drug therapy Patient assessment subsequent to CB agent exposure	Immunoassay kits Telemedicine Remote detection of vital signs
	Asymmetric threat containment	Terrorist demographics Civil liberties considerations Combatant signatures	Advanced biometrics
	Rapid response	Size and portability of equipment Safety of responders	Low-power electronics Lightweight, high-power-density batteries, power cells Accurate, all-environment, miniature laser rangefinder Real-time video Multisensor ATR Miniature downrange wind sensing Sensor fusion and NLOS weapons
	Military/law enforcement agency coordination	Communication system interoperability Multilevel security Threat information dissemination Overlapping charters	Seamless communications
	Forensic analysis	Evidence contamination	DNA recovery and analysis Post-blast modeling capabilities

Table XIII–2. Goals, Limitations, and Technologies—Combating Terrorism (continued)

Goal	Functional Capabilities	Limitations	Key Technologies
Operational Capability Element: Response (continued)			
	Post-incident recovery	Lack of critical system redundancy Logistical support for decontamination Evidence examination	Optical switches/gates Protective clothing and breathing equipment Standoff structural integrity sensors
	Dynamic threat and vulnerability analysis	Lack of integrated vulnerability analysis tools Asymmetric threat modeling	Automated information assurance Automated commander's assessment and analysis tools Automated vulnerability analysis equipment

Current capabilities for providing *protection* against terrorist attack focus on the individual soldier and fixed facilities. They include the use of body armor, CB protective suits, inoculations, and reinforced facilities and vehicles. Greater levels of protection are currently achieved through operational procedures and by limiting access. The most effective means for preventing damage from a terrorist bomb, for example, is to increase the standoff distance from potential targets by expanding the security perimeter. Where this is not possible, current capabilities for preventing structural collapse or mitigating debris hazards caused by large vehicle bombs are very limited. Modeling capabilities for assessing the effects of explosives on buildings and debris generation, chemical and biological agent dispersion in buildings and urban environments, and understanding the interdependencies of various elements of the defense infrastructure are not well developed. In addition, current capabilities for providing mass casualty medical care in response to chemical or biological attacks are limited by the availability of prophylaxes against a wide spectrum of pathogens and toxins.

Our most robust capabilities for combating terrorism lie in the area of *responding* to an incident. Capabilities for disabling threat devices when they can be found are well developed, but device diagnostic capabilities are limited. Forensic capabilities are also well developed and frequently allow attribution of an incident to a particular group. A critical weakness in this area is the ability to effectively respond to an incident when there are multiple threat devices, which is a reflection of our limited device detection capability. Decontamination and mitigation capabilities for responding to chemical or biological attacks are comparatively mature, but they rely on aqueous methods; responding to such incidents also poses many logistical challenges.

E. TECHNOLOGY PLAN

Achieving significant new capabilities for CbT requires technological advances in many different areas. The overall plan for supporting such technological advances is centered on nine new DTOs specifically established for Combating Terrorism. However, the plan relies extensively on technical progress expected to be achieved under many other DTOs as well.

Current DTOs of greatest importance to Combating Terrorism are listed in Table XIII–3. An illustration of the evolution of technology to military capabilities for combating terrorism is provided in Figure XIII–2. The relevance of each of the cited DTOs to the operational capability elements for Combating Terrorism is illustrated in Table XIII–4; the table also identifies the lead service/agency and the type of demonstration for each DTO. Detailed descriptions of all DTOs are included in the supplemental planning document titled *Defense Technology Objectives of the Joint Warfighting Science and Technology Plan and the Defense Technology Area Plan* (Reference 6). Short summaries of the nine new DTOs defined for this JWCO are provided below:

- *L.01, Entry Point Screening*, involves the development of improved technical means for screening personnel, automobiles, and cargo vehicles for the presence of dangerous materials, particularly commercial, military, and improvised explosives; and chemical, biological, and nuclear threat agent materials. New capabilities for detecting humans hidden in vehicles will also be developed.

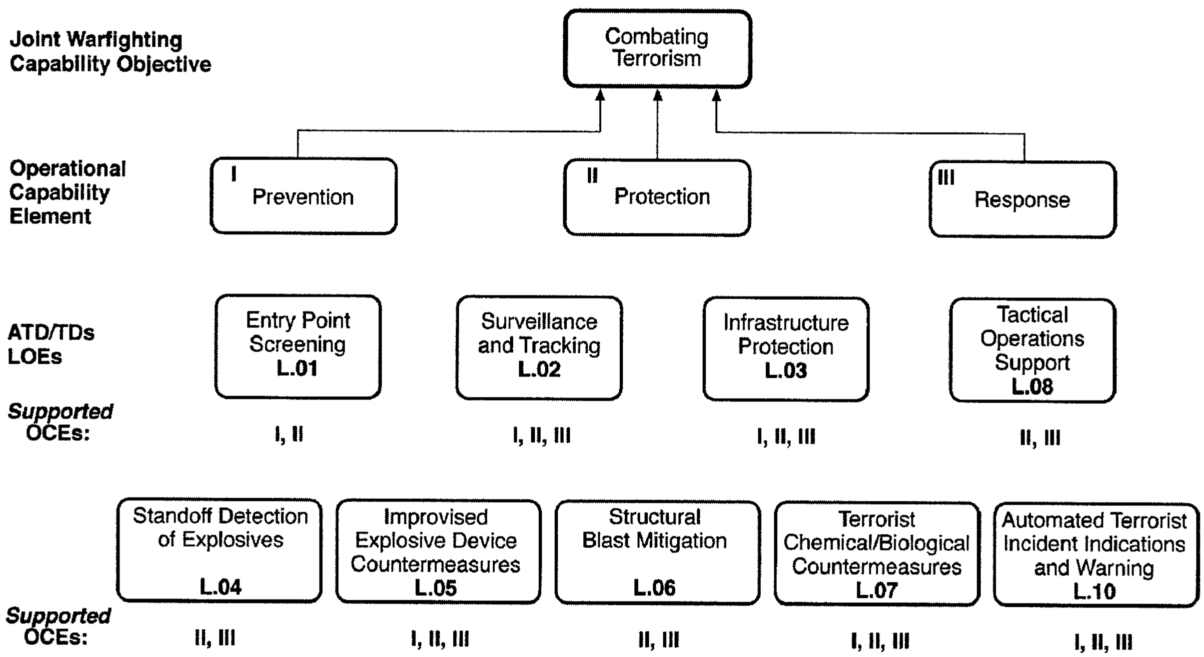
- *L.02, Surveillance and Tracking*, will lead to the development of advanced standoff audio and visual surveillance systems providing improved capabilities for identifying, monitoring, and tracking individual terrorists in the field. New through-wall surveillance capabilities enabling reliable discrimination between hostiles and friendlies in a hostage barricade situation will also be developed.

- *L.03, Infrastructure Protection*, will support the development and demonstration of advanced analytical tools for defining and mapping critical elements of the defense infrastructure, identifying and characterizing potential vulnerabilities to those elements, determining associated risks and potential consequences, and defending against attacks involving either physical or electronic means. Gaming and simulation tools for collaborative contingency and emergency planning will also be developed. Such tools do not currently exist.

- *L.04, Standoff Detection of Explosives*, will lead to the development of advanced techniques and specialized equipment enabling the detection and characterization of a variety of explosive compositions at standoff distances ranging from very short distances (<1 meter) to as much as 100 meters or more. Approaches for detecting both solid and vapor phases of explosives that are independent of concealment and access geometries will be explored, and technologies enabling the detection of explosive device components—including detonators, switches, power supplies, and wires—will be developed.

Table XIII–3. Defense Technology Objectives—Combating Terrorism

DTO No.	Title
L.01	Entry Point Screening
L.02	Surveillance and Tracking
L.03	Infrastructure Protection
L.04	Standoff Detection of Explosives
L.05	Improvised Explosive Device Countermeasures
L.06	Structural Blast Mitigation
L.07	Terrorist Chemical/Biological Countermeasures
L.08	Tactical Operations Support
L.10	Automated Terrorist Incident Indications and Warning
A.12	Information Dominance (C^2 Protect & Attack for I/O ATD)
E.01	Small-Unit Operations TD
E.02	Military Operations in Urban Terrain ACTD
E.04	Nonlethal Weapons Technical Demonstration
I.02	Joint Biological Remote Early Warning System ACTD
I.03	Airbase/Port Biological Detection ACTD
I.05	Chemical Enhancement to Airbase/Port Biological Detection ACTD
AP.20.00	DARPA Micro Air Vehicles Program
CB.06.12	Advanced Lightweight Chemical Protection
CB.07.10	Laser Standoff Chemical Detection Technology
CB.08.12	Advanced Adsorbents for Protection Applications
CB.09.12	Enzymatic Decontamination
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.19.01	Chemical Imaging Sensor
HS.05.05	Ballistic Protection for Individual Survivability
IS.21.01	Assured Communications
MD.07.J00	Medical Countermeasures for Vesicant Agents
MD.13.J00	Medical Countermeasures for Staphylococcal Enterotoxin B
MD.15.J00	Medical Countermeasures for Encephalitis Viruses
MD.16.J00	Multiagent Vaccines for Biological Threat Agents
MD.17.J00	Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases
MD.18.J00	Medical Countermeasures Against Ionizing Radiation
MD.20.J00	Diagnostic Biodosimetry Technologies
MP.05.01	Protective Materials for Combatant and Combat Systems Against Conventional Weapons
SE.59.01	Low-Light-Level Imaging Sensors



Supporting ACTD DTAP DTOs

A.12	Information Dominance (C^2 Protect and Attack for I/O ATD)
E.01	Small-Unit Operations TD
E.02	Military Operations in Urban Terrain ACTD
E.04	Nonlethal Weapons Technical Demonstration
I.02	Joint Biological Remote Early Warning System ACTD
I.03	Airbase/Port Biological Detection ACTD
I.05	Chemical Enhancement to Airbase/Port Biological Detection ACTD
AP.20.00	DARPA Micro Air Vehicles Program
CB.06.12	Advanced Lightweight Chemical Protection
CB.07.10	Laser Standoff Chemical Detection Technology
CB.08.12	Advanced Adsorbents for Protection Applications
CB.09.12	Enzymatic Decontamination
CB.14.07	Prediction and Mitigation of Collateral Hazards
CB.19.01	Chemical Imaging Sensor
HS.05.05	Ballistic Protection for Individual Survivability
IS.21.01	Assured Communications
MD.07.J00	Medical Countermeasures for Vesicant Agents
MD.13.J00	Medical Countermeasures for Staphylococcal Enterotoxin B
MD.15.J00	Medical Countermeasures for Encephalitis Viruses
MD.16.J00	Multiagent Vaccines for Biological Threat Agents
MD.17.J00	Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases
MD.18.J00	Medical Countermeasures Against Ionizing Radiation
MD.20.J00	Diagnostic Biodosimetry Technologies
MP.05.01	Protective Materials for Combatant and Combat Systems Against Conventional Weapons
SE.59.01	Low-Light-Level Imaging Sensors

Figure XIII–2. Technology to Capability—Combating Terrorism

Table XIII–4. Demonstration Support—Combating Terrorism

Demonstration	Operational Capability Elements: Prevention	Protection	Response	Service/ Agency	Type of Demonstration: DTO	ACTD	ATD	TD
Entry Point Screening	●	●		Joint	L.01			X
Surveillance and Tracking	●		○	Joint	L.02			X
Infrastructure Protection		●	○	Joint	L.03			X
Standoff Detection of Explosives	●	●		Joint	L.04			X
Improvised Explosive Device Countermeasures	○	○	●	Joint	L.05			X
Structural Blast Mitigation	○	●		Joint	L.06			X
Terrorist Chemical/Biological Countermeasures		●	●	Joint	L.07			X
Tactical Operations Support	●		●	Joint	L.08			X
Automated Terrorist Incident Indications and Warning	●			Joint	L.10			X
Information Dominance (C^2 Protect & Attack for I/O ATD)	●		●	Army	A.12		X	
Small-Unit Operations TD	○	○	●	DARPA	E.01			X
Military Operations in Urban Terrain ACTD	○	○	●	Joint	E.02	X		
Nonlethal Weapons Technical Demonstration	○	●	●	Navy	E.04			X
Joint Biological Remote Early Warning System ACTD	○	●	○	Joint	I.02	X		
Airbase/Port Biological Detection ACTD	○	●	○	Joint	I.03	X		
Chemical Enhancement to Airbase/Port Biological Detection ACTD	○	●	○	Joint	I.05	X		
DARPA Micro Air Vehicles Program	●	○		DARPA	AP.20.00			X
Advanced Lightweight Chemical Protection		●		Army	CB.06.12			X
Laser Standoff Chemical Detection Technology	○	●		Army	CB.07.10			X
Advanced Adsorbents for Protection Applications		●		Army	CB.08.12			X
Enzymatic Decontamination		●		Army	CB.09.12			X
Prediction and Mitigation of Collateral Hazards	●	○	○	DSWA	CB.14.07			X
Chemical Imaging Sensor	●			Army	CB.19.01			X
Ballistic Protection for Individual Survivability		●	●	Army	H5.05.05			X
Assured Communications	●		●	Air Force	IS.21.01			X
Medical Countermeasures for Vesicant Agents		●		Army	MD.07.J00			X
Medical Countermeasures for Staphylococcal Enterotoxin B		●		Army	MD.13.J00			X
Medical Countermeasures for Encephalitis Viruses		●		Army	MD.15.J00			X
Multiagent Vaccines for Biological Threat Agents		●		Army	MD.16.J00			X
Common Diagnostic Systems for Biological Threats and Endemic Infectious Diseases		●		Army	MD.17.J00			X
Medical Countermeasures Against Ionizing Radiation		●		Air Force	MD.18.J00			X

● Strong Support ○ Moderate Support (P) Proposed

Table XIII–4. Demonstration Support—Combating Terrorism (continued)

Demonstration	Operational Capability Elements: Prevention	Operational Capability Elements: Protection	Operational Capability Elements: Response	Service/ Agency	Type of Demonstration: DTO	Type of Demonstration: ACTD	Type of Demonstration: ATD	Type of Demonstration: TD
Diagnostic Biodosimetry Technologies		●		Air Force	MD.20.J00			X
Protective Materials for Combatant and Combat Systems Against Conventional Weapons		●		Army	MP.05.01			X
Low-Light-Level Imaging Sensors	●	○	●	Army	SE.59.01			X

● Strong Support ○ Moderate Support (P) Proposed

- *L.05, Improvised Explosive Device Countermeasures*, supports the development of new equipment and systems that will enable explosive ordnance teams (EOTs) to safely access large vehicle bombs and other improvised explosive devices (IEDs), conduct diagnostic procedures, and render them safe for subsequent handling and disposal. This work will include the development and testing of both precision and general explosive device disruption techniques.

- *L.06, Structural Blast Mitigation*, will provide new techniques for mitigating shock effects and damage in structures, improved building design and refortification methods, and advanced vulnerability-assessment tools for evaluating and reducing the effects of explosive blasts on structures. The work will focus on reducing debris hazards (the major cause of injuries to personnel in terrorist bomb attacks) and on preventing structural collapse (the major cause of fatalities).

- *L.07, Terrorist Chemical/Biological Countermeasures*, supports the development of improved capabilities for detecting and identifying various chemical and biological agents prior to or after their deployment. The effort will include the development of a time-amount profile dosimeter for measuring individual exposures, new methods and materials for mitigating agent effects, and appropriate medical care and cleanup procedures.

- *L.08, Tactical Operations Support*, will contribute to the development of advanced technological capabilities and equipment required by military forces responsible for the planning and execution of antiterrorist and counterterrorist operations. Specific efforts will include developments involving advanced sensors, weapons, information and communications systems, targeting systems, and improved protective measures for tactical forces.

- *L.10, Automated Terrorist Incident Indications and Warning*, will develop and demonstrate an automated profiling capability and a system architecture for scanning large databases and providing cues and information linkages regarding potential terrorists activities and plans prior to the actual occurrence of anticipated incidents. Development of such capabilities will enable U.S. forces to implement suitable protective measures and—when sufficient information is available—to execute appropriate counterterrorist

actions to prevent expected attacks. These capabilities will also direct personnel to take protective actions to remove themselves from the effects of the terrorist attack.

The JWSTP DTOs supporting combating terrorism include selected DTOs in the areas of Information Superiority, Military Operations in Urban Terrain (MOUT), and Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction. Relevant DTAP DTOs include selected DTOs in the areas of Air Platforms; Chemical/Biological Defense and Nuclear; Information Systems Technology; Biomedical; Materials and Processes; Sensors, Electronics, and Battlespace Environment; and Human Systems. Effectively integrating the numerous and diverse activities involved in developing required new capabilities for combating terrorism into a manageable technology plan represents a formidable challenge. A technology roadmap illustrating the planned pathway to the realization of many new capabilities for combating terrorism is provided in Figure XIII–3.

F. SUMMARY

The operational capabilities and technologies required to combat terrorism reflect the dynamic and diverse nature of terrorism itself. Emphasizing the critical priority of force protection, the technology investments addressed in this plan cover the full spectrum of CbT objectives: deterrence of terrorist incidents, employment of countermeasures, mitigating the effects of terrorist incidents, and incident recovery. The associated DoD science and technology programs will demonstrate and evaluate a wide range of many promising technology opportunities for improving U.S. capabilities for combating terrorism. Figure XIII–4 summarizes the expected progress that will be accomplished in this area over the next 3–6 years.

This plan for Combating Terrorism responds to the needs of the Joint Warfighter and has been developed as a JWCO in accordance with the Chairman's Program Recommendations (CPRs). Through a detailed review of the Defense Planning Guidance (DPG), the plan has been developed in coordination with the Joint Staff, the Integrated Priority Lists (IPLs) from the five operational CINCs, and the services.

CbT leverages limited resources and focuses on technologies and demonstrations that offer significant improvement in Force Protection capability while simultaneously incorporating some degree of operational legacies. Evolutionary development is the preferred approach in order to quickly field required capabilities that provide an adequate solution in the near term but offer clear potential for upgrade as technologies mature. Successful execution of the wide range of R&D efforts cited in this plan will greatly improve the capability of the Joint Warfighter by reducing the terrorist threat worldwide.

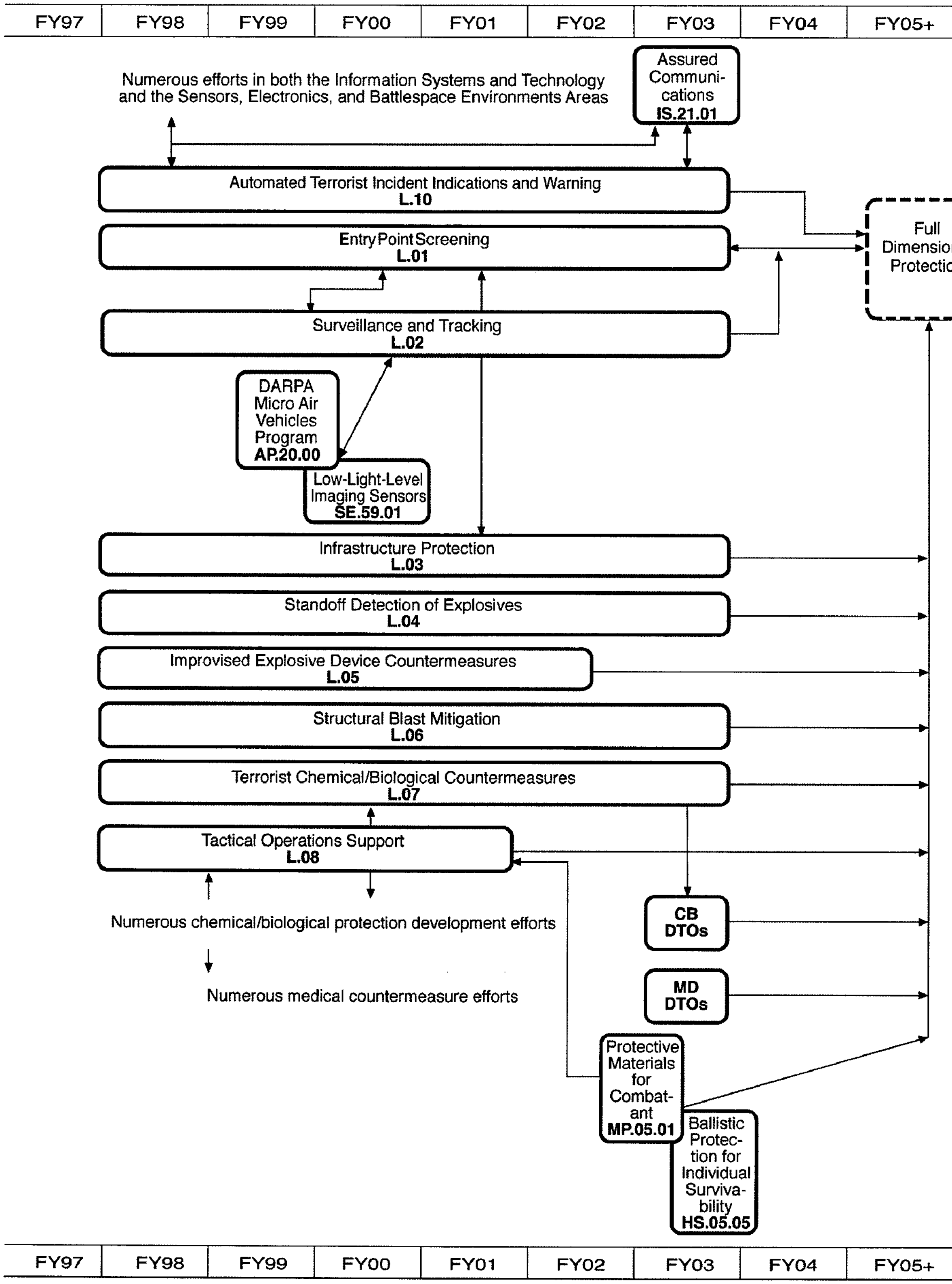


Figure XIII–3. Roadmap—Combating Terrorism

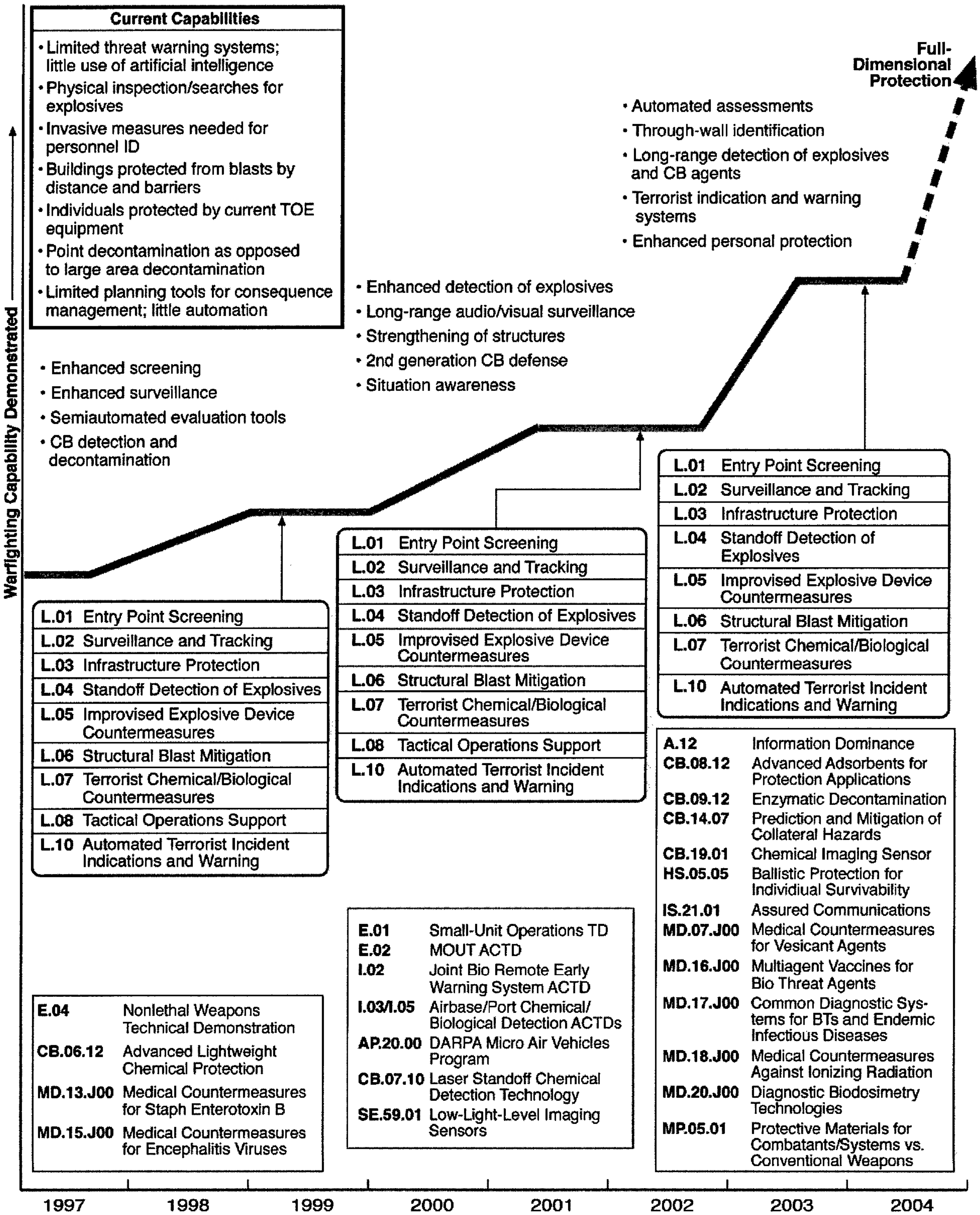


Figure XIII–4. Progress—Combating Terrorism

GLOSSARY AND REFERENCES

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

3D	three dimensional
ABIS	Advanced Battlespace Information System
ABL	airborne laser
ACTD	Advanced Concept Technology Demonstration
ADS	authoritative data source
ADSAM	air-directed surface-to-air missile
AGE	aerospace ground equipment
AGTFT	Antijam GPS Technology Flight Test
AIEWS	Advanced Integrated Electronic Warfare System
AJP	advanced joint planning
ALERT	air/land enhanced reconnaissance and targeting
ALISS	Advanced Lightweight Influence Sweep System
AMC	Army Materiel Command
AMCM	airborne mine countermine
ASCIET	All-Service Combat Identification Evaluation Team
ASIC	application specific integrated circuit
ASTAMIDS	Airborne Standoff Minefield Detection System
ATACMS	Army Tactical Missile System
ATD	Advanced Technology Demonstration
ATIRCM	advanced threat infrared countermeasure
ATR	automatic target recognition
AUV	autonomous underwater vehicle
BADD	battlefield awareness and data dissemination
BAMB	bending annular missile body
BAT	Brilliant Antitank
BC^2A	Bosnia Command and Control Augmentation
BCID	battlefield combat identification
BCIS	Battlefield Combat Identification System
BDA	battle damage assessment
BMDO	Ballistic Missile Defense Organization
BPI	boost-phase intercept
BRP	*Basic Research Plan*
BW	biological warfare
C&C	cut and cover
C^2	command and control
C^2I	command, control, and intelligence
C^2W	command and control warfare
C^3	command, control, and communications
C^3I	command, control, communications, and intelligence
C^4	command, control, communications, and computers
C^4I	command, control, communications, computers, and intelligence
C^4ISR	command, control, communications, computers, intelligence, surveillance, and reconnaissance
CAS	close air support
CATOX	catalytic oxidation
CB	chemical and biological
CBIRF	Marine Corps Chemical Biological Incident Response Force

CbT	Combating Terrorism
CBW	chemical and biological warfare
CC&D	camouflage concealment and deception
CEC	U.S. Navy Cooperative Engagement Capability
CECOM	U.S. Army Communications–Electronics Command
CEP	circular error probable
CID	combat identification
CIGSS	Common Integrated Ground/Surface System
CIMMD	close-in man-portable mine detector
CINC	commander in chief
CJTF	Commander Joint Task Force
CM	countermeasure
CMMS	conceptual models of the mission space
COA	course of action
COBRA	coastal battlefield reconnaissance and analysis
COE	common operating environment; Center of Excellence
CONOPS	concept of operations
CONUS	continental United States
CORBA	Common Object Request Broker Architecture
COTS	commercial off-the-shelf
CP	counterproliferation
CP&CBD	counterproliferation and chemical/biological defense
CPI	Counterproliferation I
CPII	Counterproliferation II
CPR	Chairman's Program Recommendations
CPRC	Counterproliferation Program Review Committee
CSS	combat service support
CTF	common technical framework
CW	chemical warfare
CWMD	counter weapons of mass destruction
DARPA	Defense Advanced Research Projects Agency
DCOR	Defense Committee on Research
DDR&E	Director, Defense Research and Engineering
DIA	Defense Intelligence Agency
DII	Defense Information Infrastructure
DIRCM	directional infrared countermeasure
DIS	distributed interactive simulation
DISC/DIAL	differential scattering/differential absorption of light
DLA	Defense Logistics Agency
DMSO	Defense Modeling and Simulation Office
DNA	deoxyribonucleic acid
DoD	Department of Defense
DOE	Department of Energy
DOF	degree of freedom
DOTES	doctrine, organization, training, equipment, and support
DPG	Defense Planning Guidance
DRFM	digital radio frequency memory
DSB	Defense Science Board
DSP	Defense Support Program
DSTAG	Defense Science and Technology Advisory Group

DSWA	Defense Special Weapons Agency
DTAP	*Defense Technology Area Plan*
DTD	digital topographic data
DTO	Defense Technology Objective
DUSD	Deputy Under Secretary of Defense
DUSD(AT)	Deputy Under Secretary of Defense (Advanced Technology)
DUSD(A&T)	Deputy Under Secretary of Defense (Acquisition and Technology)
EA	electronic attack
EC	electronic combat
ECM	electronic countermeasure
EHF	extremely high frequency
ELB	extending the littoral battlefield
EM	electromagnetic
EMI	electromagnetic interference
EN–ATD	Explosive Neutralization Advanced Technology Demonstration
EN–Tech Demo	Explosive Neutralization Technology Demonstration
EO	electro-optic(al)
EOD	explosive ordnance demolition; explosive ordnance disposal
EOT	explosive ordnance team
EP	electronic protection
EPA	Environmental Protection Agency
ERT	enhanced reconnaissance and targeting
ES	electronic support
ESM	electronic support measure
ESSM	Evolved Sea Sparrow Missile System
EW	electronic warfare
EXCOM	Executive Committee
FAC	forward air controller
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration
FET	field effect transistor
FLIR	forward-looking infrared
FPA	focal plane array
FXXILW	Force XXI Land Warrior
FY	fiscal year
FYDP	Future Years Defense Plan
GaAs	gallium arsenide
GBR	ground-based radar
GCCS	Global Command and Control System
GCSS	Global Combat Support System
GHz	gigahertz
GOTS	government off the shelf
GPS	Global Positioning System
GTN	Global Transportation Network
HAARP	High-Frequency Active Auroral Research Project
HAE	high-altitude endurance
HD	humanitarian demining

HDBTDC	Hard or Deeply Buried Target Defeat Capability
HDRRM	high-density radiation-resistant microelectronics
HF	high frequency
HLA	high-level architecture
HMMWV	High-Mobility Medium-Wheel Vehicle
HPAC	Hazard Prediction Assessment Capability
HPM	high-power microwave
HQ	headquarters
HQDA	Headquarters, Department of the Army
HS	Human Systems
HSOK	hunter/standoff killer
HUMINT	human intelligence
HVM	hypervelocity missile
IA:AIDE	information assurance: automated intrusion detection environment
IADS	Integrated Air Defense System
IBAD	Interim Biological Agent Detector
IBAS	Improved Bradley Acquisition System
ICM	integrated collective management; integrated collection management
ID	identification
IED	improvised explosive device
IFF	identification friend or foe
IFOR	Implementation Force
IIR	imaging infrared
IMINT	imagery intelligence
IMS	ion mobility spectroscopy
I/O	information operations
IO	information operations
IOPT	information operations planning tool
IPB	intelligence preparation of the battlefield
IPE	individual protection equipment
IPL	Integrated Priority List
IPT	Integrated Process Team
IR	infrared
IRCM	infrared countermeasure
IS	information superiority
IS&T	information systems and technology
ISR	intelligence, surveillance, and reconnaissance
IW	information warfare
IW–D	defensive information warfare
IWG/CT	Interagency Working Group on Counterterrorism
JAHUMS	Joint Advanced Health and Usage Monitoring System
JAMC	Joint Amphibious Mine Countermeasure
JBC	Joint Battle Center
JBREWS	Joint Biological Remote Early Warning System
JCAD	Joint Chemical Agent Detector
JCM	joint countermine
JCOS	Joint Countermine Operational Simulation
JCS	Joint Chiefs of Staff
JCSE	joint continuous-strike environment

JDAM	Joint Direct Attack Munition
JDST	Joint Decision Support Tool
JFLCC	Joint Forces Land Component Commander
JMRR	Joint Monthly Readiness Report
JPO–BD	Joint Program Office for Biological Defense
JPP/RTS	Joint Power Projection/Real-Time Support
JRAMS	Joint Readiness Automated Management System
JROC	Joint Requirements Oversight Council
JSIMS	Joint Simulation System
JTAV	Joint Total Asset Visibility
JTF	Joint Task Force
JTMD	joint theater missile defense
JTR	joint training readiness
JTS	Joint Training Simulator
JUXOCO	Joint Unexploded Ordnance Coordination Office
JV 2010	*Joint Vision 2010*
JWARN	Joint Warning and Reporting Network
JWARS	Joint Warfare Simulation
JWCA	Joint Warfighting Capability Assessment
JWCO	Joint Warfighting Capability Objective
JWE	Joint Warfighting Experiment
JWSTP	*Joint Warfighting Science and Technology Plan*
KE	kinetic energy
kHz	kilohertz
km	kilometer
LAD	Logistics Anchor Desk
LADAR	laser radar
LCAC	landing craft air cushion
LCPK	low-cost precision kill
LDTOC	Light Digital Tactical Operations Center
LOCAAS	low-cost antiarmor submunition
LOS	line-of-sight
LOSAT	Line-of-Sight Anti-Tank System
LPD	low probability of detection
LPI	low probability of intercept
L/V	lethality/vulnerability
LW	Land Warrior
LWIR	long wavelength infrared
m	meter
M&S	modeling and simulation
MAA	Mission Area Analysis
MAE	medium-altitude endurance
MAGTF	Marine Air–Ground Task Force
MALD	miniature air-launched decoy
MC&G	mapping, charting, and geodesy
MCM	mine countermeasures
MEADS	Medium Extended Air Defense System
MEMS	microelectromechanical systems

MH/K	mine hunter killer
MLRS	Multiple-Launch Rocket System
MLS	multilevel security
mm	millimeter
MMIC	monolithic microwave integrated circuit
MMT	miniaturized munition technology
MNS	Mine Neutralization System, Mission Need Statement
MOE	measure of effectiveness
MOP	measure of performance
MOUT	military operations in urban terrain
MPM	microwave power module
MRC	major regional conflict
MRL	multiple rocket launcher
MSRR	modeling and simulation resource repository
MSTAR	moving and stationary target acquisition and recognition
MTI	moving target indicator
MUDSS	Mobile Underwater Debris Survey System
MURI	Multidisciplinary University Research Initiative
MWS	Missile Warning System
NATO	North Atlantic Treaty Organization
NBC	nuclear, biological, and chemical
NDI	nondevelopmental item
NEDT	noise-equivalent delta temperature
NGO	nongovernment organization
NLOS	non-line-of-sight
NMD	National Missile Defense
NRDEC	Natick Research, Development, and Engineering Center
NRT	near-real time
NSC	National Security Council
NSTC	National Science and Technology Council
NTM	national technical means
O&M	operations and maintenance
OASD(C^3I)	Office of the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)
OATSD(CBM)	Office of the Assistant to the Secretary of Defense for Chemical and Biological Matters
OBEU	onboard electronic countermeasure upgrade
OCE	Operational Capability Element
ODCSOPS	Office of the Deputy Chief of Staff for Operations and Plans
ODDR&E	Office of the Director, Defense Research and Engineering
OICW	Objective Individual Combat Weapon
ORSMC	off-route smart mine countermeasure
OSD	Office of the Secretary of Defense
OSTP	White House Office of Science and Technology Policy
OUSD(A&T)/S&TS/EW	Office of the Undersecretary of Defense for Acquisition and Technology/Strategic and Tactical Systems/Electronic Warfare
P^3I	preplanned product improvement
PAC-3	PATRIOT Advanced Capability 3
P_d	probability of detection

PDM	program decision memorandum
PIC	Program Integration Council
POM	program objective memorandum
PRCMRL	Precision Rapid Counter Multiple Rocket Launcher
PRG	Program Review Group
PSA/TSA	pressure-swing adsorption/temperature-swing adsorption
PSTS	Precision SIGINT Targeting System
PTI	precision targeting identification
RTV	rapid terrain visualization
QDR	Quadrennial Defense Review
R&D	research and development
RAMICS	Rapid Airborne Mine Clearance System
RF	radio frequency
RFCM	radio frequency countermeasures
RFPI	Rapid Force Projection Initiative
ROV	remotely operated vehicle
RSM	radar signal modulation
RTIC	real-time information in the cockpit
s	second
S&T	science and technology
SA	situation awareness
SABER	Situation Awareness Beacon with Reply
SAIP	semi-automated imagery processing
SAR	synthetic aperture radar
SAS	situational awareness subsystem
SAW	surface acoustic wave
SBIRS	Space-Based Infrared System
SEAD	suppression of enemy air defense
SEI	specific emitter identification
SENGAP	Small Engine Advanced Program
SFOR	Security Force
SHARP	System-oriented High-range-resolution Automatic Recognition Program
Si	silicon
SiC	silicon carbide
SIGINT	signals intelligence
SIT	static induction transistor
SM-2	Standard Missile 2
SOF	Special Operations Forces
SO/LIC	special operations/low-intensity conflict
SORTS	Status of Resources and Training System
SSM	surface-to-surface missile
STIL	Streak Tube Imaging LIDAR
STOW	synthetic theater of war
SUO	small unit operations
T/R	transmit/receive
TA	target acquisition
TAC	tactical command post

TACAIR	tactical aircraft
TAPSTEM	Training and Personnel Systems Science and Technology Evaluation Management
TARA	Technology Area Review and Assessment
TBM	theater ballistic missile
TC AIMS II	Transportation Coordinator Automated Information Management System II
TD	Technology Demonstration
TDA	tactical decision aids
TEM	Terrain Evaluation Module
TEU	Technical Escort Unit
THAAD	Theater High-Altitude Area Defense System
TLAM	Tomahawk Land Attack Missile
TMD	theater missile defense
TPEDIT	Time-Phased Force Deployment Data Editor
TPSO	Theater Precision Strike Operations
TSWG	Technical Support Working Group
TTP	tactics, techniques, and procedures
TUAV	tactical unmanned aerial vehicle
TWMP	Track Width Mine Plow
TWMR	Track Width Mine Roller
TRADOC	U.S. Army Training and Doctrine Command
TUGS	tactical unattended ground sensor
UAV	unmanned aerial vehicle
UFO	UHF follow-on
UGS	unattended ground sensor
UGV	unattended ground vehicle
UHF	ultra-high frequency
UJTL	Universal Joint Task List
U.K.	United Kingdom
U.S.	United States
USACOM	United States Atlantic Command
USEUCOM	United States European Command
USMC	United States Marine Corps
USSOCOM	U.S. Special Operations Command
UUV	unmanned underwater vehicle
UV	ultraviolet
UXO	unexploded ordnance
VHF	very high frequency
VHSIC	very high speed integrated circuit
VMF	variable message format
VMMD	vehicle-mounted mine detector
VV&A	verification, validation, and accreditation
w	watt
WMD	weapons of mass destruction

REFERENCES

1. *Defense Science and Technology Strategy*, Director of Defense Research and Engineering, May 1996, reprinted January 1997.

2. *Basic Research Plan*, Director of Defense Research and Engineering, January 1997.

3. *Defense Technology Area Plan*, Director of Defense Research and Engineering, January 1997.

4. *Joint Vision 2010*, Joint Chiefs of Staff, 1996.

5. *National Security Science and Technology Strategy*, National Science and Technology Council, 1995.

6. *Defense Technology Objectives of the Joint Warfighting Science and Technology Plan and the Defense Technology Area Plan*, Director of Defense Research and Engineering, February 1998.

7. *Report of the Quadrennial Defense Review*, Secretary of Defense, May 1997.

8. *Report of the National Defense Panel*, National Defense Panel, December 1997.

9. *Advanced Concept Technology Demonstration (ACTD) Master Plan*, Deputy Undersecretary of Defense for Advanced Technology, August 1996.

10. *Chairman of the Joint Chiefs of Staff Instruction S-3210.01,* January 2, 1996.

11. *Department of Defense Dictionary of Military and Associated Terms,* Joint Pub 1–02, March 23, 1994 [http://www.dtic.mil/doctrine/jel/dodict/].

12. *Command and Control: The Literature and Commentaries*, National Defense University, September 1993.

13. *Advanced Battlespace Information System*, Task Force Final Report, May 1996.

14. R. Steeb et al., *Rapid Force Projection: Exploring New Technology Concepts for Light Airborne Forces*, Documented Briefing, Arroyo Center, National Defense Research Institute, DB–169–A/OSD, 1996.

15. R. Steeb et al., *Rapid Force Projection Technologies: A Quick-Look Analysis of Advanced Light Indirect Fire Systems*, Documented Briefing, Arroyo Center, National Defense Research Institute, DB–168–A/OSD, 1996.

16. *Defense Science Board 1994 Summer Study on Military Operations in Built-up Areas.*

17. *Nuclear Weapon System Sustainment Programs*, Office of the Secretary of Defense, May 1997, World Wide Web [http://defenselink.mil/pubs/dswa/].

18. *Modeling and Simulation Management Plan*, Deputy Secretary of Defense Memorandum, June 21, 1991 (incorporated in DoD Directive 5000.59).

19. *Report to Congress on Unexploded Ordnance Clearing: A Coordinated Approach to Requirements and Technology Development*, Under Secretary of Defense for Acquisition and Technology, March 25, 1997.

20. *Concept for Future Joint Operations* (CFJO), Joint Chiefs of Staff, May 1997.

21. *Department of Defense Counterproliferation (CP) Implementation*, Department of Defense Directive (DoDD) 2060.2, July 9, 1996, ASD(ISP).

22. *Conduct of the Persian Gulf War* (CPGW), Department of Defense, April 1992.

23. *Report on Activities and Programs for Countering Proliferation and NBC Terrorism*, Counterproliferation Program Review Committee (CPRC), May 1997 [http://www.acq.osd.mil/cp.nbc97.htm].

24. *A National Security Strategy for a New Century* (NSS 97), The White House, May 1997 [http://www.acq.osd.mil/cp/nbc97].

25. *Proliferation: Threat and Response* (PTR II), Office of the Secretary of Defense, October 1997 [http://www.defenselink.mil].

26. *Proliferation: Threat and Response* (PTR I), Office of the Secretary of Defense, April 1996 [http://www.defenselink.mil/pubsprolif/toc.html].

27. *DoD Response to Transnational Threats*, 1997 Defense Science Board Summer Study.

28. *Khobar Towers: The Downing Task Force Report*, Secretary of Defense, August 1996.